The Massachusetts Volunteer Monitor's Guidebook to Quality Assurance Project Plans

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Additional copies can be requested from:

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This report is also available at the MADEP, Division of Watershed Management's home page on the World Wide Web at:

http://www.state.ma.us/dep/brp/wm/wmpubs.htm

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Introduction to the QAPP

The intent of this workbook is to provide you with the maximum amount of assistance in preparing your Quality Assurance Project Plan. A large part of what you need to know is contained in an excellent EPA document, "The Volunteer Monitor's Guide to Quality Assurance Plans" (EPA, 1996) <http://www.epa.gov/owow/monitoring/volunteer/qappcovr.htm>. This guidebook is intended as a supplement to that EPA Guide.

You should know two things about the QAPP requirement: 1) it is probably the most important part of your planned effort to improve the environment because good quality assurance planning (the QAPP process) leads to the collection of data of known and documented quality; and 2) you are not alone in being required to develop a QAPP. All monitoring efforts receiving EPA or Massachusetts Environmental Agency funding must develop a QAPP, including those same agencies.

There are some things for you to think about from the beginning; and as you go through this process, you may want to come back to these initial ideas and modify them. A useful analogy is the purchase of a car. You should ask yourself what you intend this car to do. Do I need some basic short mileage transportation or will I be driving tens of thousands of miles a year? Is comfort or style important? How long should it last? What can I afford? How many people or how much stuff do I want to carry?

Translated into water quality monitoring language, these questions are: Do I have a specific short-term purpose in mind, e.g. stop that farmer from dumping his manure on the side of the stream? Or do I want a broad-based program that will help solve several problems in my watershed and monitor long-term trends? Are the goals only to make the citizenry more aware of environmental quality and how it is measured or are we also trying to effect a solution? How long should this program go on and what can be reasonably expected of volunteers in the short and long term? If this is a long-term effort, what will need to be done for motivation and recruitment? What's your funding base and is this sustainable? How many problems should you tackle and what people, equipment, and financial support are required?

The answers to these questions will largely determine the content of your QAPP. Because the QAPP forces you to think in the long term, it helps to avoid the major pitfalls that earlier volunteer efforts often discovered.

How to Use the Guidebook

We are basing this guidebook on the general template of the U.S. EPA Guide (EPA, 1996), that is, there are 24 discrete elements to a QAPP. Chapter 2 of the EPA Guide provides a good overview of 11 recommended steps (listed in the text box that follows) a volunteer monitoring program would take in preparing a QAPP. We recommend that you familiarize yourself with this chapter before you start researching information, recruiting help and writing your QAPP.

11 STEPS TO DEVELOPING A QAPP

Step 1: Establish a QAPP team

Step 2: Determine the goals & objectives of your project

Step 3: Collect background information

Step 4: Refine your project

Step 5: Design your project's sampling, analytical & data requirements

Step 6: Develop an implementation plan

Step 7: Draft your standard operating procedures (SOPs) & QAPP

Step 8: Solicit feedback on your draft SOPs & QAPP

Step 9: Revise your QAPP & submit it for final approval

Step 10: After the QAPP is approved, begin your monitoring project

Step 11: Evaluate and refine your Project and revise the QAPP

Adapted from EPA (1996)

The form of this Guidebook follows that defined by Chapter 4 of the EPA Guide. Each of the following sections is based on an EPA Guide element and the brief description of the element in the EPA Guide (EPA, 1996) is repeated at the beginning of each section. This guidebook's style will be to follow the EPA Guide information and format with a more detailed explanation of 1) the information that needs to be provided, 2) the location of supporting information, and 3) examples of how to present that information where appropriate. To construct your own response for your QAPP, you will need to use a variety of resources. The guidebook takes three approaches to assuring that these resources will be readily available. In many cases, the text and supporting tables provide all or most of the information needed so that you simply need to choose the relevant parts. For those materials that are specific to your locality or are readily available, the guidebook will suggest contacts for the materials. For other material that may either be difficult to obtain, take significant time to obtain or have substantial cost, this

guidebook is backed by a website (http://www.umass.edu/tei/mwwp/qapp.html) where these items may be viewed and downloaded by anyone with access to the world wide web. For example, if you are doing water quality analyses, you may need to cite, include and use the appropriate method from an EPA publication or Standard Methods. These documents are relatively expensive to purchase and contain much more information than you will need. Those portions that are relevant to most volunteer water quality monitoring will be available from the web. If you have access to the world wide web, you may want to access the copy of this guidebook (http://www.umass.edu/tei/mwwp/qapp.html) so that as you read along, you can access the numerous information links easily. If you do not have web access, contact the Massachusetts Water Watch Partnership or the sources directly (see Appendix 1). If technical terms are mystifying, consult Appendix 2 for explanations.

This workbook cannot possibly cover the entire range of possible monitoring that you might consider. Our intent is to cover the basics. For elements not covered in this workbook, we encourage you to contact the Massachusetts Water Watch Partnership (MWWP), the Massachusetts Department of Environmental Protection, or the New England office of EPA (see Appendix 1 for contact information). The Partnership will maintain a library of approved QAPPs, information and recommendations on various equipment available, and the full descriptions of all EPA and Standard Methods techniques in the latest editions of those manuals. The QAPP library is categorized so that you can quickly find the example QAPP that best fits your needs.

We encourage you to follow the EPA Guidebook and this Guidebook's format and to cut and paste appropriately modified information from this guidebook. It is not our intent to make development of your QAPP simply a cut-and-paste exercise. Most sections should require some careful consideration of your project goals, budget and available volunteer power. When those decisions are made, however, the user will find it helpful to have the EPA Guide, this Guidebook and, if possible, the web version of the Guidebook readily available as the QAPP is developed.

It is our hope that the information provided here makes the QAPP task easier and more thorough. It is also our hope that our efforts beyond this guidebook and the QAPP library provide future assistance that will lead to your success in this project, your larger environmental goals, and the general improvement of Massachusetts waters.

Timing For Success

As this guidebook indicates, there's a lot of work required to get your QAPP out the door and you are still not done when the draft is mailed. One or more agencies will review it, and you will probably have at least a minor, possibly a major, rewrite to do, based on written comments and conversations with the reviewers. All this takes time, so you must make sure you start the process far enough in advance to ensure that your QAPP receives final approval *before* you start monitoring. A helpful hint is that misunderstandings or disagreements between you and your QAPP reviewer can usually be much more quickly resolved by phone or a meeting than by mail.

Here's a suggested timeline (Table I.1) for accomplishing the different steps, but it will vary with the number of people involved, the amount of needed background research, and the complexity of your project. Additional information on scheduling is contained in a Massachusetts Water Watch Partnership report "Starting a Volunteer Monitoring Program" <http://www.umass.edu/tei/mwwp/starting.html>.

Table I.1. Estimated Timelines for QAPP process.

Months prior to monitoring	6	4	2	1	0
Recruit QAPP team	XXXXXX XXX				
Determine goals & objectives	XXXXXX				
Collect background information	XXX XXXXXX		XXXXXX	(as necessary)	
Refine project scope	XXXXX				
Design sampling, analytical & data requirements	XXXXXX				
Develop an implementation plan	XXXXX				
Draft SOPs	X	XXXXXX			
Write and submit your draft QAPP		XXXXXX XXX			
Solicit feedback on draft SOPs & QAPP		XXXXXX			
Revise your QAPP and submit for final approval			XXXXXX XX		
Final changes?				XXXX	
Start sampling					XXXXXX

While the steps outlined in the EPA guide provide a logical sequence for writing your QAPP, the order of the elements in the QAPP are more suited to the review process. You will find that you are developing information on many elements at a time during your planning process and returning to elements as the decision process continues. Therefore, it may be most efficient to create files for each element and add information as it develops.

Where to Submit your QAPP

You will have to submit your QAPP to the following address, regardless of your source of funding. MA DEP will determine if your QAPP should be reviewed by other state and federal agencies and distribute to others if warranted.

MA DEP Quality Assurance Officer (Arthur Screpetis, MA DEP)
627 Main St., 2nd Floor
Worcester MA 01608
508/767-2875
arthur.screpetis@state.ma.us

The draft QAPP should be transmitted with a cover letter that describes the purpose of the project or proposed monitoring activity, identifies the funding source(s) and agency contact(s), and identifies when sampling is expected to begin.

You may receive review comments from other agency QAPP reviewers and may need to communicate with them directly. Their addresses are shown below.

State and Federal QAPP Contacts:

EPA

EPA- New England QAPP reviewers:

Steve DiMattei, US EPA
US EPA
11 Technology Drive
N. Chelmsford, MA 01863-2431
phone (617) 918-8369;
fax (617) 918-8397;
dimattei.steve@epa.gov

Arthur Clark, US EPA:
US EPA
11 Technology Drive
N. Chelmsford, MA 01863-2431
phone: (617) 918-8374
fax: (617) 918-8397
clark.arthur@epamail.epa.gov

MADEP

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fax: (508) 791-4131
arthur.johnson@state.ma.us

24 STEPS TO A SUCCESSFUL QAPP
THE QAPP ELEMENTS

1. Title and Approval Page

Your title page should include the following:

- title and date of the QAPP

- names of the organizations involved in the project

- names, titles, signatures, and document signature dates of all appropriate approving officials such as project manager, project QA officer, and, if the project is funded by EPA, the EPA project manager and QA officer

EPA, 1996

Purpose: To identify the project leadership and those who approved the QAPP.

What to Include:

Include the following information on the title sheet . . .

- **Date** of submission
- The **responsible agency** is the name of your organization.
- The **Project Manager** is the person who will have general oversight over all aspects of the project and will be the principal contact person.
- The project **QA (Quality Assurance) officer** ***should not*** be the same person as the Project Manager, if at all possible, since these have the potential to be conflicting roles. The QA officer might be someone on the project's technical advisory committee or one of the volunteers.
- The **MA Project Manager** is the person from MA DEP assigned to your project (if applicable).
- The **MA Agency QA Officer** is the person from MA DEP who will review and approve this QAPP.
- The **EPA-NE Project Manager** is the person from EPA-New England assigned to your project (for EPA funded projects).
- The **EPA-NE QA Officer** is the person from EPA-New England QA Unit who will review this QAPP (for EPA funded projects).

Format to Use:

The form below (Table 1.1) is an example of an acceptable format for the title and approval page.

Table 1.1. Format for the Title Page.

_____

(Project Name)

_____

(Responsible Agency)

_____

(Date)

Project Manager _____

(Signature)

_____

(Name - typed) (Date)

Project QA Officer _____

(Signature)

_____

(Name - typed) (Date)

MA Agency Project Manager _____

(Signature)

_____

(Name - typed) (Date)

MA Agency QA Officer _____

(Signature)

_____

(Name - typed) (Date)

EPA-NE Project Manager _____

(Signature)

_____

(Name - typed) (Date)

EPA-NE QA Officer _____

(Signature)

_____

(Name - typed) (Date)

2. Table of Contents

A Table of Contents should include section headings with appropriate page numbers and a list of figures and tables.

EPA, 1996

Purpose: To enable the reader to quickly find information**.**

Format to Use:

The format and numbering should follow that shown in the EPA QAPP guide to facilitate the external review of your QAPP. All pages must be numbered and the sections must be in logical order, preferably the same order as the 24 elements in the EPA Guide. Limited license to combine some sections is permitted if combination is justified and reduces redundancy. Deviations from that format should be noted and justified.

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3. Distribution List

List the individuals and organizations that will receive a copy of your approved QAPP and any subsequent revisions. Include those listed on the approval page and representatives of all groups involved in your monitoring effort.

EPA, 1996

Purpose: To enable the reader to know who has received this QAPP and how to contact them.

What to Include:

Don't forget any organization or agency that is either helping you organize and carry out your monitoring program or is going to use your results. Addresses (street, telephone, fax, and email) should be provided here and in Section 4.

Examples:

Recommended

1. Project Manager
2. QA Officer
3. MA Agency Project Manager
4. MA Agency QA Officer
5. USEPA Project Officer (if applicable)
6. USEPA QA Officer (if applicable)
7. Project Field Supervisor
8. Project Lab Supervisor
9. Key Volunteers

Optional

10. Town Boards, e.g. City Council, Selectboard, Planning Board, Conservation Commission, Board of Health, Zoning Board
11. Regional Planning Agency
12. Regional MA Agency Office
13. Massachusetts Water Watch Partnership
14. Monitoring Support Center

Maintain a file copy of this approved QAPP in an accessible place for all volunteers and interested public to examine.

4. Project/Task Organization

Identify all key personnel and organizations that are involved in your program, including data users. List their specific roles and responsibilities. In many monitoring projects, one individual may have several responsibilities. An organizational chart is a good way to graphically display the roles of key players.

EPA, 1996

Purpose: To show the reader how your project is organized and who does what.

What To Include

The roles and responsibilities should include the following:

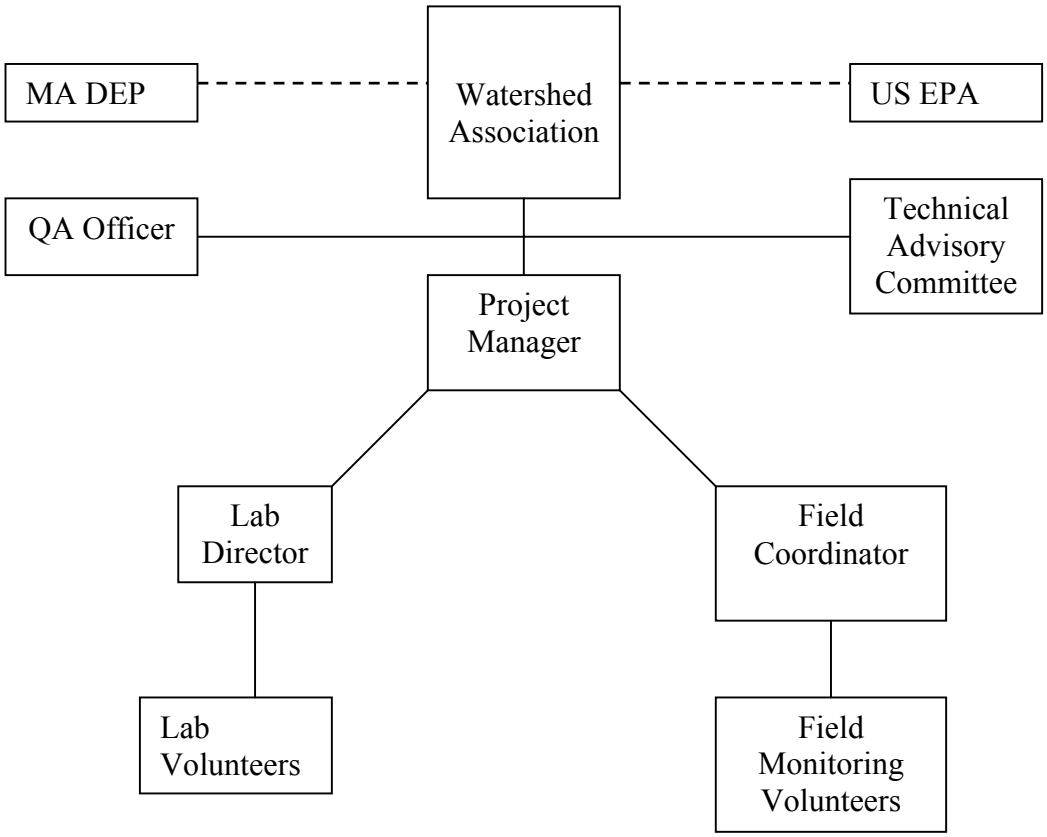
1. The responsible agency is the organization responsible for ensuring that all aspects of the project are performed as described in the approved QAPP.
2. The Project Manager is responsible for directing all project activities for the lead organization and for submitting the QAPP.
3. The technical advisory committee (TAC) should consist of technically-trained personnel with experience in data collection and use, quality control, and your watershed. The TAC should provide primary assistance in identifying project objectives, data quality objectives, and appropriate sampling and analytical methods.
4. The QAPP preparation team/writer should be familiar with all aspects of the QAPP development and have training in environmental science or related field.
5. Project personnel should include those people with significant responsibility for following the QAPP, such as the monitoring coordinator and laboratory director.
6. EPA-New England and state agency personnel include those responsible for approving the QAPP and the final project results.

We suggest that you develop job descriptions for each position, even volunteers!

We strongly encourage you to develop a technical advisory committee (TAC) to help throughout the project and especially in making the choices necessary in designing your study and completing the QAPP. The makeup of the TAC should reflect the complexity of your project. Additional help (and perhaps members of your TAC) may be found at the Monitoring Support Centers (MSCs) for your area, the Massachusetts Water Watch Partnership and your Watershed Team Leader. The most up-to-date Monitoring Support Center list will be maintained on the Water Watch Partnership web site <http://www.umass.edu/tei/mwwp/msc.html>. Alternatively, call the Water Watch Partnership for an up-to-date listing (see Appendix 1 for contact information).

Format to Use:

We suggest developing a chart of your organizational structure that clearly shows who will make decisions about various parts of the project. An example is shown below.



All key personnel should be listed along with their addresses (street, telephone, fax, and email) and responsibilities. Following is the suggested format (Table 4.1), using an example from the Deerfield River Watershed QAPP (addresses not shown in example below for reasons of privacy).

Table 4.1. Example Table of Key Personnel.

Title	Responsibility	Name	Address / Phone / email*
Responsible Agency	Fiscal management of the project, project objectives, data uses, program changes, etc.	Deerfield River Watershed Association	
Technical Advisory Committee	Primary assistance in identifying project objectives, data quality objectives and methods, and oversight of project assessment.	Christine Duerring (contact), Robert Walker, Sandy Shields, Marie-Françoise Walk, Dawn Peters	
Project Manager	Directs all project activities for the agency and oversees development and evaluation of the QAPP.	Roland Hesselbart	
QA Officer/QAPP writer	Assists with or writes the QAPP and ensures that all elements of the project follow QA procedures in the QAPP.	Marie-Françoise Walk,	
Laboratory Director	Oversees or conducts all lab analyses and ensures that all QA procedures in the lab QAPP are followed.	Sandy Shields, Greenfield Water Pollution Control Facility	
Monitoring Project Coordinator	Coordinates all elements of the field monitoring, provides training to volunteers and assesses field monitoring performance.	Noreen Martin, DRWA Administrative Assistant	
MADEP QA officer	Reviews the QAPP for accuracy and completeness.	Richard Chase	
DEP project officer	Ensures that all agency reporting requirements are met	Arthur Johnson	

* Left blank in this Guidebook for privacy reasons; these should be provided in your QAPP.

5. Problem Definition/Background

In a narrative, briefly state the problem your monitoring project is designed to address. Include any background information such as previous studies that indicate why this project is needed. Identify how your data will be used and who will use it.

EPA, 1996

Purpose: This section defines the problem so the reader can match your purpose with your monitoring approach.

What to Include

This section should clearly spell out the issues of interest and the purpose of your study. The statement of purpose will govern your choices in all the following sections so it must be accurate, complete and well-considered. Reviewers of the QAPP will be evaluating the match between your purpose and your selection of sampling process, sampling methods, analytical methods, quality control, data management, and validation. It may be best to develop this section as a draft, revisiting it as the consequences of your choices become clearer.

This section typically includes: organization description, watershed/waterbody description, current status of your waters of interest, pressing water quality issues, information needed to address issues, monitoring questions and purposes, and intended users. Nevertheless, this section need not be very long – a few paragraphs to a few pages. Most of the information on your project will be described in more detail in later sections. The rationale and supporting information for your project should be made clear in this section.

How to Decide What to Do

There is real complexity behind this section, even though the description may be relatively simple and the example below is relatively brief. In fact, decisions made in completing this section and the next govern what goes into most of the rest of the QAPP.

To get to your question and data uses and users, we suggest that you consider and include the following information:

Describe your organization: Include your mission and major goals in a few sentences. This will give the reader a sense of who your group is and what it does. It provides the organizational context for your monitoring program. Hopefully, you have this information readily available.

Describe your watershed and your waters of interest: This is a basic description of the geography of your watershed to give the reader a sense of place. Include any information on ecoregions, physiographic regions, hydrology, topography, and climate (see Appendix 1) which will give the reader a sense of the watershed. Define which waters in your watershed you will focus on. Include in the listing of those waters, the PALSARIS number for each. These unique code numbers for each lake or stream are available in two MADEP reports (Halliwell et al., 1982; Ackerman et al., 1984).

Describe the current status of your waters of interest: List your waters of interest and their status under the MA water quality laws and regulations. The state reports to EPA and Congress every two years with a list of all the waters of the state and the extent to which they support their designated uses under the state water quality standards. As part of this process, the state develops a list of all the waters in the state and whether they, fully, partially, or don't support their protected uses. The uses themselves are designated by the state as suitable for drinking, for swimming or other recreation, etc. Definitions for designated uses, a list of waterbodies and their designated use, and criteria required for a water body to support a designated use can be found in the Massachusetts Surface Water Quality Standards Regulations. These can be downloaded at <http://www.state.ma.us/dep/brp/wm/files/314cmr4.pdf>. Here it will be helpful to review the water quality standards and the various state reports that assess the impairment status of your waters. Information on whether a water body actually meets its designated use is kept in what is known as the "305(b)" reports produced by DEP and submitted to EPA <http://www.state.ma.us/dep/brp/wm/wmpubs.htm>. Waters that will not meet the water quality standards appear in the "303(d)" or "impaired waters" list. This can be downloaded at <http://www.state.ma.us/dep/brp/wm/files/finalist.pdf>. Your knowledge of problems and threats is also critical, regardless of the state's assessment of their status. Other studies may have been conducted on your waterbody. These should be cited; their results should be summarized in the QAPP and factored into your deliberations. Include the following information:

1. What water uses are designated to be protected under the water quality standards?
2. What are the actual existing uses and values?
3. Have the waters been assessed?
4. Are the waters impaired (303d listed)?
5. What are the sources of impairment?
6. What are the causes of impairment (contaminants).
7. What are the known problems, conflicts, or threats
8. What are the known efforts to address problems?

Note that these lists are often based on incomplete information and the true status of a water body is unknown. The issue your monitoring program might address, in this case, is the lack of information as to your waters' current status.

State the most pressing water quality issue(s) facing your waters of interest: Based on your research, briefly describe the issues that will need to be addressed for your stream, lake or estuary. Issues can be existing or potential conflicts among or impacts to uses and values. A few examples might be:

1. Loss of riparian or lakeshore habitat to development
2. Recreation impairment caused by pollution from inadequate/failing on-site septic systems
3. Increased turbidity from motorboat activity
4. Aquatic life impairment due to sedimentation
5. Invasive weeds or excessive macrophyte growth
6. Shellfish contamination.
7. Lack of information of current health of water body.

Describe the information needed to address the issues: Think about the key issues you identified above. What information might you need to address them? What information would you need to restore riparian or lakeshore habitat, for example? Identify the key characteristics, conditions and processes that you wish to monitor and where you wish to monitor them. Try to identify some of the general conditions and processes you might want to monitor in the field. For example, your research might turn up the fact that there are fish kills in the late summer in a particular stream reach or lake embayment and the causes are unknown. You may want to focus on those areas and processes that affect fish health.

List your monitoring questions: We suggest that any monitoring program should start with one or more questions, the answers to which provide essential information that addresses issues faced by decision-makers in your watershed. Your monitoring activities should then be designed to answer these questions. For example, if the issue you're concerned about is a conflict between a waste discharge and swimming at your favorite swimming hole, you might frame the following monitoring question: *Is swimming in the swimming hole a health risk?* If your issue is the threat of polluted runoff from a large paved area on a river, you might frame the following question: *What is the impact of the parking area on the ecological health of the river?* If the loss of lakeshore vegetation is your issue of concern, you might frame the following question: *What is the impact of the loss of shoreline vegetation on aquatic plants and animals in the littoral zone?* Questions can be framed many ways, but the more specific the better.

What are your monitoring purposes? Unless you have lots of free time on your hands, you want your monitoring effort to collect the most useful information with the least amount of time and expense. An important first step is to identify why you want to collect this information: the purpose of your monitoring. According to recent guidance for effective state monitoring programs (Yoder, 1997), there are five general purposes for monitoring:

1. Define present watershed conditions.
2. Characterize existing and emerging problems by type, magnitude and geographic extent.
3. Provide information to help design strategies to reduce and control pollution and to manage land and water.
4. Provide information for evaluating the effectiveness of reduction, control and management strategies.
5. Reveal trends in watershed quality.

List the intended uses and users of the information you collect: Identify the decision-makers who are (or should be) interested in the answers to your questions. Find out what actions they might take or decisions they might make as a result of your information. List these decision-makers (users) and the actions or decisions (uses). Consult with the decision-makers to find out if and under what circumstances they will use your information.

The selection of data uses and data users has consequences that ripple throughout the rest of the QAPP process. Your project might have a primary goal of increasing the awareness and involvement of middle school kids or, at the other extreme, you might want to initiate a lawsuit against a polluter. In between is a continuum of project complexity and rigor. Your choice will largely be determined by your selection of the data uses and users. This Guidebook focuses its help on the most common purposes of volunteer monitoring efforts, the five listed on the previous page. With the help of your technical advisory committee and others (Monitoring Support Centers and agency contacts, you can modify these by adding or subtracting complexity and rigor.

How To Gather the Information

EPA recommends contacting existing monitoring programs and agencies to obtain information about current and past water quality conditions, suggested monitoring sites, etc. Some groups also hold public meetings wherein local folks offer suggestions about what to monitor for and where to do it. A common tactic is to post large maps (topographic or GIS maps) on the wall of such a meeting and have participants place color-coded stickers on the map signifying special resource areas and known or suspected problem spots. The program design team and technical advisory committee take this input and fashion a monitoring plan.

Watershed or shoreline surveys can be a valuable part of the project design process. For guidance on conducting such surveys, refer to Appendix 1 for available resources. When in doubt, contact your Monitoring Support Center (Appendix 1)

The table below (Table 5.1) summarizes the process that has been developed and tested by many volunteer groups and lists the resources that contain additional information.

Table 5.1. Information Gathering Process.

Tasks	Purpose	How to accomplish	Examples of Methods
Assemble existing material	Ensure all information, issues are brought to light	Literature Search	Review state/federal reports, town plans, previous studies
Identify special resource areas	Guide decisions on where, what to monitor	List of uses, values and threats	Meeting participants locate uses, values and threats on a map.
Expand and update information	Keep current, verify older info sources	Visual Field Survey	Conduct: Windshield Watershed Survey, Shoreline Survey for Volunteers, River Walk and/or Watershed Non-point Source Evaluation and Site Assessment
Achieve consensus and prioritize issues	Ensure that program decisions are widely agreed to, focus limited resources on most important issues.	Determine what others are already doing. Identify what you need to know to address the issues, better define the problem or evaluate the effectiveness of solutions. Select those questions that are most important and manageable for your group.	Meet with your TAC Consensus building Facilitated discussion
Identify data uses and users	Helps you determine what steps you must take to get your data accepted for your intended objectives	An assessment of the types of data to be collected and the quality of data required by decision-makers	VEMN Study Design Workbook (see Appendix 1)

Formats to Use:

You can use a narrative format or table format, or both to present background information. Below (Table 5.2) is the suggested format for a table that summarizes your waters' current status.

Table 5.2. Table Format that Summarizes the Current Status of Your Waters of Interest

Water Body ID (PALSARIS #)	**Designated Uses (from 305b report)**	**Actual Uses & Values** (from your own experience)	**Waters Assessed? Y or N (from 305b report)**	**Uses Supported? Y or N (from 305b report)**

Source of Impairment (from 303d list)	**Cause of Impairment** (from 303d list)	**Known Problems, Conflicts, or Threats** (from your experience or other studies)	**Known Efforts To Address Problems** (from your experience or other studies)

Information Sources:

For more information, specific to your watershed type (river, lake, estuary), these websites provide excellent descriptions of the ecosystem, typical problems and approaches that volunteers might use.

1. Streams: <http://www.epa.gov/owow/monitoring/volunteer/stream> (U.S. EPA, 1997).
2. Lakes: <http://www.epa.gov/owow/monitoring/lakevm.html> (U.S. EPA, 1991).
3. Estuaries: <http://www.epa.gov/owow/monitoring/estuarvm.html> (U.S. EPA, 2000).

Also recommended are the documents developed by the Merrimack River Volunteer Environmental Monitoring Network (VEMN). Information on obtaining paper copies is presented in Appendix 1.

- Training manual for core VEMN monitoring parameters and methods <http://www.umass.edu/tei/mwwp/acrobat/vemn-manual.PDF.> (VEMN, 1996)
- VEMN guide to volunteer watershed monitoring options in the Merrimack River Watershed <http://www.umass.edu/tei/mwwp/qapp.html> (VEMN, 1996)
- VEMN Merrimack River Watershed Study Design Workbook*:* <http://www.umass.edu/tei/mwwp/acrobat/studydesign.PDF> (VEMN, 1995)

Several of the following resources will probably need to be used in developing this section:

- Massachusetts Surface Water Quality Standards Regulations <http://www.state.ma.us/dep/brp/wm/files/314cmr4.pdf>. (314 CMR 4.00)
- "303(d)" or "impaired waters" list <http://www.state.ma.us/dep/brp/wm/files/finalist.pdf>(MADEP, 1999).
- Appropriate topographic maps <http://www.umass.edu/tei/esio/>
- Maps of land use (MassGIS <http://www.state.ma.us/mgis>, town Planning Boards and Conservation Commissions)
- Population data in the watershed and location. (MassGIS may also be able to help here. County and town population data can be obtained from this site: <http://www.umass.edu/miser/dataop/data.htm>.
- Existing monitoring information (possible sources and web sites) are:
    1. The Mass. Dept. of Environmental Protection (MADEP) <http://www.state.ma.us/dep> (DEP publishes a list of studies it's conducted from 1963 – 1999: "Publications of the Division of Watershed Management, 1963 – 1999"; find it at <http://www.state.ma.us/dep/brp/wm/wmpubs.htm#other>.
    2. The Mass. Dept. of Environmental Management (MADEM) <http://www.state.ma.us/dem/>,
    3. The Mass. Dept. of Fisheries, Wildlife and Law Enforcement (MADFWELE) <http://www.state.ma.us/dfwele/>, including the Office of Endangered Species and Division of Fisheries;
    4. EPA Region 1 <http://www.epa.gov/region1/>, or EPA "Surf Your Watershed" site (information on every watershed in the country – some WQ info, Superfund sites, permitted discharges, etc.): <http://www.epa.gov/surf3/>,
    5. town Conservation Commissions and Planning Boards,
    6. local colleges, and environmental consulting firms that may have worked in the watershed.
- Existing point source discharge information (MADEP NPDES reports. Contact your regional DEP office - <http://www.state.ma.us/dep/dephome.htm> or Appendix 1 tells you how to reach them.)
- Existing information on industry and commercial types, water use, stormwater discharges, and wastewater treatment plants (town Conservation Commissions, Planning Boards and Public Works, Regional Planning Agencies).

6. Project/Task Description

In general terms, describe the work your volunteers will perform and where it will take place. Identify what kinds of samples will be taken, what kinds of conditions they will measure, which are critical, and which are of secondary importance. Indicate how you will evaluate your results--that is, how you will be making sense out of what you find. For example, you may be comparing your water quality readings to State or EPA standards, or comparing your macroinvertebrate evaluations to State-established reference conditions or historical information.

Include an overall project timetable that outlines beginning and ending dates for the entire project as well as for specific activities within the project. The timetable should include information about sampling frequency, lab schedules, and reporting cycles.

EPA, 1996

Purpose: To provide an overview of your monitoring program.

What to Include:

This section should briefly summarize the monitoring program you've designed to address the problems and issues you identify in section 5. Elements of this section include:

- **Watershed issues** to be addressed from Section 5.
- **Measurements to be taken** that will describe those conditions in order to address the watershed issues (e.g. watershed, habitat, chemical, and/or biological).
- **What type of samples you will collect** (e.g. visual examination, grab sample, integrated sample, direct measurement, fish or shellfish, qualitative net collection, semi-quantitative net collection, quantitative rock basket, other.
- **The temporal frequency** of your sampling: monthly, weekly, daily, event, other.
- **The spatial frequency** of your sampling: Rivers: regular intervals along stream, upstream/downstream of potential source, at bridge crossings, etc. Lakes: mid-lake, deep hole, coves and bays, tributary inlets and outlet, etc. Estuaries: regular intervals, near potential sources, coves and bays, inlets, etc.
- **The importance of each type of measurement**: Critical or secondary
- **How you will evaluate your results**: comparison to State or EPA standards <http://www.state.ma.us/dep/brp/wm/files/314cmr4.pdf>, comparison with State reference collections (contact MADEP, Worcester), upstream/downstream comparison, comparison with other water bodies, comparison with previous data, etc.
- **A list of the tasks and a timetable within which they will be carried out**: what will happen and when.

So, this section describes the choices you've made about the basic design of your program. Remember that you will provide more detail in sections that follow (especially sections 10-13), so don't go into too much depth here. Much of the specific information behind this section will become clearer with the completion of these later sections. After you have initially tried to fill in as much as possible, bookmark this section for later revision. The reason for an initial attempt is that the table gives one a good sense for how interrelated the choices that are made later will become and an even better sense of whether you may be diluting your efforts by trying to focus on too many issues.

How to Decide What To Do

You challenge is to move from the watershed issues you identified in section 5 to specific choices about what, when and where to monitor. Here your Technical Advisory Committee or your Monitoring Support Center can help.

To help you narrow down this task a bit, we present the approach used by the Merrimack River Volunteer Environmental Monitoring Network (VEMN). The VEMN identifies a number of common surveys that address watershed issues for most programs:

1) **Preliminary Watershed Assessment -** a visual survey and evaluation of some basic watershed characteristics to help identify issues, watershed uses and values, and problem areas to guide field monitoring activities.

2) **Water Contact Health Risk Assessment -** a combination of water sampling for contaminants of concern and data gathering on exposure to contaminants and actual disease occurrence to see if there's a relationship between water quality, exposure, and illness.

3) **Water Quality Standards Assessment** - water sampling and analysis of river or lake water quality indicators that the states of Massachusetts and New Hampshire use to determine how well our waters comply with state standards for their designated uses.

4) & 5) **Basic and Rigorous Baseline Monitoring: Rivers and Lakes -** collection of information by various activities about some of the basic physical, chemical and biological conditions. This information is used as a "baseline" or benchmark against which to assess future changes.

6) & 7) **Basic and Rigorous Wastewater Treatment Plant Impact Assessment -** collection of information by various activities about the impact of a wastewater treatment plant on the water body's (primarily rivers in Massachusetts) ecological health and human use.

8) & 9) **Basic and Rigorous Non-point Source Impact Assessment -** collection of information about the impact of runoff from a non-point pollution source on the river's ecological health and human use.

10) **Non-point Source Site Evaluation -** a systematic approach for trained volunteers to visually evaluate the seriousness of non-point source pollution. This evaluation takes place at a particular site and focuses on the production, transport, and control of runoff on the site.

11) **Stormwater Discharge Monitoring -** focuses on locating pipes that discharge stormwater (as opposed to sanitary wastewater) and sampling the effluent coming out of those pipes during dry and wet weather to determine its quality and potential to affect rivers and lakes.

12) **Wastewater Compliance Survey -** the review of discharge monitoring reports to determine whether the discharge complies with the NPDES permit.

13) **Hypoxia Survey –** focuses on the loss of dissolved oxygen in near-bottom waters of lakes and estuaries as a result of excessive loads of organic matter.

14) **Shellfish Survey –** focuses on the extent and cause of bacterial contamination of shellfish in estuaries.

Each type of survey has a typical menu of indicators from which a final list is selected. These are listed below (Table 6.1). Other indicators may be added for specific anticipated circumstances.

Table 6.1. Tools or Indicators Normally Used in Each Type of Survey

	Survey # (see List Above for Type)													
Measures	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**
Research Existing Information	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Visual field surveys	X	X	X	X	X	X	X	X	X	X	X	X		X
Bacteria		X	X	X	X	X	X	X	X		X			X
Dissolved Oxygen			X	X	X	X	X						X	
Turbidity (River/Estuary)			X	X	X	X	X	X	X		X			
Secchi Transparency (Lake/Estuary)			X	X	X									
Temperature			X	X	X	X	X				X			X
pH			X	X	X	X	X				X			
Total Alkalinity				X	X	X								
Conductivity				X	X	X	X				X			
Total Phosphorus				X	X	X	X	X	X		X			
Nitrogen - Total Kjeldahl					X		X		X					
Nitrogen - Nitrate				X	X	X	X	X	X					
Nitrogen - Ammonia					X		X		X					
Intensive Benthic Macroinvertebrate Assessment (Rivers)					X		X		X					

	Survey # (see List Above for Type)													
Measures	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**
Streamside Benthic Macroinvertebrate Assessment				X		X		X						
Benthic Macroinvertebrate Habitat Assessment (Rivers)					X		X		X					
Flow (Rivers)					X			X	X					
Longitudinal Profile (Rivers)					X				X					
Channel cross-section (Rivers)					X				X					
Biological Oxygen Demand, BOD (Rivers/Estuaries)						X	X				X		X	
Chlorophyll a (Lakes/Estuaries)					X									
Aquatic Vegetation Mapping/Identification				X	X									
Lake level					X									
Embeddness (Rivers)								X	X					
Bottom Composition (Rivers)								X	X					
Precipitation								X	X					
Salinity (Estuaries)				X	X	X	X	X	X		X			
Suspended Solids	X		X	X	X	X	X	X	X	X	X			

Information Sources

The VEMN has developed a series of guides and workbooks that walk you through the process of making these choices. These are available as Acrobat files that may be downloaded and viewed or printed in whole or in part <http://www.umass.edu/tei/mwwp/qapp.html>. Information on obtaining paper copies may be found in Appendix 1. This guidebook relies heavily on that work but with less detail.

Similarly, EPA has developed Volunteer Methods Manuals for Rivers, Lakes, and Estuaries.

Streams: <http://www.epa.gov/owow/monitoring/volunteer/stream/> (U.S. EPA, 1997).

Lakes: <http://www.epa.gov/owow/monitoring/lakevm.html> (U.S. EPA, 1991).

Estuaries: <http://www.epa.gov/owow/estuaries/monitor/> (U.S. EPA, 2000).

The Massachusetts Water Watch Partnership has additional guidance on running a volunteer monitoring program <http://www.umass.edu/tei/mwwp/starting.html>.

Your choice as to which type of survey best fits your project goals and your selection of appropriate measures tailored to fit your specific project needs should be made carefully with the advice of your Technical Advisory Committee and other experts. The tables above are intended as possible starting points but are not intended to confine your choices or be all inclusive.

Formats To Use

After making your choices, the project/task description is probably best presented as a narrative using tables only to support the narrative. The narrative should discuss and justify the issue of focus for your project, the measures you will use, how and how often the samples will be taken, and how you will compare your data with other information. Since some measures, sampling sites, dates, etc. may be extremely important to your project while others may be useful but not so critical, these should be distinguished. This will be important when you write element 7. Your project/task description should also contain a timetable for the key parts of the project. This may be presented in table form; Table 6.2 or Table 6.3 are possible styles to use.

Table 6.2. Project Timetable Format 1

Activity	Start Date	Completion Date
Overall Project	January 1, 2000	December 31, 2000
Task 1, e.g volunteer recruitment	January 1, 2000	March 30, 2000
Task 2, e.g. monthly chemical sampling	March 1, 2000	October 30, 2000
Task 3, e.g. data processing	July 1, 2000	December 31, 2000
Interim Program Report	Quarterly	
Final Program Report		December 31, 2000

Table 6.3. Project Timetable Format 2 (Gantt Chart)

Year (s)

Activity	J	F	M	A	M	J	J	A	S	O	N	D
Overall Project	■	■	■	■	■	■	■	■	■	■	■	■
Task 1 e.g. volunteer recruitment	■	■	■	■	■							
Task 2 e.g. monthly chemical sampling					■	■	■	■	■	■		
Task 3 e.g. data processing						■			■	■	■	
Interim Program Report			■			■			■			
Final Program Report												■

Any chart or text that adequately defines the timetable of the project is acceptable.

Remember that this element is intended to be an overview or an abstract of your project. The supporting details will be stated in the following sections. So like most good abstracts, it probably should be completed last, after the details are finalized. It should also be concise. The intent is to provide the QAPP reviewer with the essence of your project so that the later elements may be evaluated more effectively.

7. Data Quality Objectives (DQOs) for Measurement Data

Data Quality Objectives (DQOs) are the quantitative and qualitative terms you use to describe how good your data need to be to meet your project's objectives. DQOs for measurement data (referred to here as data quality indicators) are precision, accuracy, representativeness, completeness, comparability, and measurement range. Provide information on these indicators, in quantitative terms if possible. See Chapter 3 for a further discussion of these terms.

Since it is important to develop a QAPP prior to monitoring, it may not be possible to include actual numbers for some of the data quality measurements within the first version of the document. You will need, however, to discuss your goals or objectives for data quality and the methods you will use to make actual determinations after monitoring has begun. You must also discuss at what point changes will be made if project specifications are not achieved. Data quality indicators should be given for each parameter your are measuring, in each "matrix" (i.e., substance you are sampling from, such as water or sediment). The easiest way to present quantitative information is in a table

In some types of monitoring, particularly macroinvertebrate monitoring and habitat assessment, some data quality indicators cannot be quantitatively expressed. In that case, you can fulfill this requirement of the QAPP by citing and describing the method used and by providing as many of the data quality indicators as possible (e.g. completeness, representativeness, and comparability) in narrative form.

EPA, 1996

Purpose: To describe how good your data need to be to meet your data use needs and those of your data users.

What to Include:

This section is also intended to be a relatively concise statement. It should be in narrative form with supporting tables.

- An opening statement that your goal is to produce data of sufficient quality to be acceptable to your intended audience(s) as identified in Section 5.
- A list of parameters you will test showing desired targets for precision, accuracy and measurement ranges (particularly the minimum detection level) you expect to achieve for each.
- How you will determine accuracy and precision for each parameter. Don't be too detailed because the detail will be most appropriate in section 14.

- A narrative description of representativeness, comparability and completeness for your overall sampling effort, that is, not parameter by parameter. For comparability, mention any past studies that yours is supposed to compare with; either state that your methods are similar or explain any differences that might limit comparability.
- A discussion of what you'll do if you don't meet your targets. This is also an overview; the details will be specified in section 20.

How to Decide What to Do:

One way to think of data quality objectives (DQOs) is as the outer limits beyond which your data will not be useful for your project's purposes. The users of your data have (or will) set their own data quality objectives (limits) when they consider using your data. Consequently, it is very important that your data users are involved in the setting of your DQOs. But don't try to anticipate the needs of all possible users of your data. Your project will become unnecessarily complicated and expensive. Focus on your goal and the data users that will help you achieve that goal.

Data quality objectives are expressed as accuracy, precision, representativeness, completeness, comparability, and measurement range. These are described below. In all cases, you should determine what you need to achieve your project goals and then match those needs with methods or instruments, not the opposite.

- **Precision** is the degree of agreement among repeated measurements of the same indicator and gives information about the consistency of your methods.
- **Accuracy *or* Bias** is a measure of confidence that describes how close a measurement is to its "true" value.
- **Measurement Range** is the range of reliable readings of an instrument or measuring device in actual use on real samples; both the upper and lower limits that you might expect must be considered. To help in determining the measurement range for your project and also help you to properly select methods or instruments that will meet your needs, your measurement range should reflect the part of the total "expected" range that your study will encounter, and your methods or instruments should provide a detection limit that can properly measure that range.

  Expected Range, as shown in Table 10, is the range of readings normally expected for Massachusetts waters. The measurement range relevant to your project will generally fall within the expected range. The measurement range of the device should include all of your expected measurement range with a little to spare, otherwise the measuring device is not appropriate. If you do not know the measurement range for your project, the expected range shown in Table 10 is a useful starting place.

  Detection Limits include several different types, and it is important to understand the difference because it affects your choice of methods and instruments. Only the Method Detection Limit (MDL) or Practical Quantitation Limit (PQL) is relevant for your QAPP, but you will probably encounter the others in product specifications or

other studies. Since the other limits provide a rosier picture of the method or instrument capabilities, it is extraordinarily important for your project that you make sure your MDL or PQL matches the measurement range.

Instrument detection limit (IDL) is three times the standard deviation above the instrument noise level, for practical purposes the lower limit of the indicator that the instrument is capable of detecting. This is the value commonly reported in instrument advertisements.

Lower level of detection (LLD) is the level of measurement that can be reproduce with 99% certainty, everything else remaining constant. It is typically twice the IDL.

Method detection limit of (MDL) is the level of measurements that can be reproduced with 99% certainty after going through the entire analytical method by an experienced operator. It is typically four times the IDL. Reporting Detection Limit (RDL) is sometimes used synonomously with MDL.

Practical quantitation limit (PQL) that is the level that several labs can achieve using the same samples. The PQL is customarily about four to five times the MDL or ten times the IDL.

For most instrument specifications, IDL is reported. For most methods, MDL is reported.

The question for your project is whether the MDL or PQL (if you use more than one lab for the same analysis) matches or is lower than the lowest value of your expected range for each parameter, reporting limit requirements, action limit, or regulatory requirements as set by federal or state agencies. For example, if you need to determine total phosphate values as low as 0.005 mg/l (5 ppb), the MDL or PQL must be 0.005 mg/l or lower. QAPP reviewers will check that your methods and instruments are appropriate for your target measurement range .

- **Representativeness** is the extent to which measurements actually represent the true environmental condition. The key elements are:
  - the appropriateness of your sampling site selection for describing the general characteristics of the water body and specific impacts.
  - the appropriateness of the location of the sample collection point: spatial location (mid-stream, mid-lake, etc.), sampling depth, number of sites, etc.
  - the appropriateness of the parameters to the type of impact. Later sections evaluate these issues in greater detail and should be consistent with the statement here.
- **Comparability** is the degree to which data can be compared directly to similar studies. There are two things to consider: future studies someone might undertake and past studies you (or others) will want to compare your data with. By using standardized sampling, analytical methods, and units of reporting, and documenting them in your QAPP, you have addressed the first case. For existing studies, you should review the studies and look for several things. Are their choices (e.g. purpose of study, selection of

indicators, methods, sampling sites, sampling frequency) documented? If so, will your design follow theirs? Any departures from these earlier studies – either because you can't determine how they conducted the study or because you can't or won't follow their methods (e.g. sites are no longer accessible or sampling equipment is different) should be discussed. Your Technical Advisory Committee might help you decide how to address differences. Your QAPP should state why you think differences between studies will not affect comparability (e.g. because you think different methods remain equivalent) or to what degree comparability will be compromised by the differences in study design. Projects that promise improvement based on the combination of monitoring and implementation need to give special consideration to comparability so as to be positioned to demonstrate that implementation was successful.

Comparability should include:

- Correspondence with sites used by other investigators or with historical information.

- Equivalence of sampling and analytical methods and reporting units.

- **Completeness** is an estimate of the amount of data you will need to answer your study question. You need to consider the overall number of samples needed, as well as the number needed at particular sites and under any different conditions dictated by your study question. For example, suppose you are trying measure bacterial contamination of a river reach under both wet and dry conditions. Your completeness statement might state "A total of 80 samples over the course of the season will be required to determine the health of a river reach. We will plan to collect 100 samples from 10 sites on 10 different sampling days between April and October. We will sample at least 8 times at sites 1, 3, 4, 5, 7, 8, 9, and 10, which are considered critical sites. Of the 10 sample dates, at least 2 will be sampled under wet weather conditions, and all of the critical sites will be sampled on these days." Completeness can only be guessed at the beginning stages. By building a sufficient degree of "overkill," as in the example, you insure yourself against sample collection problems or volunteer absenteeism.

"The objective of this section is to satisfy your intended data users that your measurements produce data that are valid for the stated purpose of your study. A common question among QAPP writers is "how much accuracy and precision is enough?" Ideally, your data users would tell you what would satisfy them. But in reality, this does not frequently happen; there are too many potential users to consult them, they may not know in advance or won't want to say what they would require. We suggest you determine your accuracy and precision goals by taking following steps.

1) Confer with your EPA or MA Agency QA officer. See what they suggest.

2) Consult other groups who have done similar studies.

3) Consult Table 7.1, below. This provides examples from QAPPs written by other volunteer monitors. Bear in mind, however, that these are all excerpts from specific studies, each with a particular objective. Lifting these these examples directly to your QAPP might

be like taking a quote out of context. The purpose of a study has a bearing on how rigorous accuracy and precision requirements need to be. You might want to use this table as a starting point, until you get information more pertinent to your own study.

4) Determine what is feasible. If you have done previous studies, or you know others who have performed similar studies, how well did the field and lab personnel perform? Calculate the accuracy and precision obtained in those studies, and use those figures.

If you use step 4, you may need to reconcile differences between what you think you can attain and what others think you should attain. Consult your TAC, and see what compromise is possible. It won't do you any good to set goals that are impossible to match. On the other hand, it won't help to set goals that are very easy to meet but that allow technique so sloppy that no one trusts your data. If you find there's a large disparity between your past or projected performance and user expectations, you may need to revise your sampling design. There are several options:

- selecting different methods
- finding a different lab to conduct your analyses
- increasing your volunteer training and/or QC activities
- modifying your data use objectives (e.g. deciding to use your data for general education instead of submitting to DEP for use in their 305(b) report
- reducing the scope of your study – i.e. drop this parameter altogether.

Table 7.1. Example Data Quality Objectives for Typical Parameters Measured by Volunteers in Massachusetts.

These example DQO's are based on the range of analytical methods and field/lab instrumentation available to volunteers, and on historical results for quality control samples, where available. Each volunteer group must determine project goals, select project-based equipment, assess field and lab capabilities, and review historical quality control data, in order to choose reasonable project-specific data quality objectives.

Indicator	Units	Minimum Detection Limit	Accuracy/Bias[1,2]	Overall Precision[3]	Approx. Potential Range[4]
DO	mg/l	0.0	+0.5 for zero standard	<0.5 difference between dups	0.0-15.0
BOD	mg/l	0.0	Within lab control limits for glucose-glutamic acid and dilution water blank checks	<1.0 difference between dups	0.0-10.0
Temperature	°C	0.0	±0.5 °C in comparison to NIST-traceable thermometer	+/- 0.5 °C	0.0-30.0
Conductivity	µS/cm	25	±5% of known QC std.	10% RPD	10-2000 (freshwater)
pH	pH units	NA	±0.2 of QC standard	± 0.2	4.0-10.0
TP (water)	mg/l P	0.005	80-120 % recovery for QC std. and lab fortified matrix	± 0.005 mg/l if less than 0.050 mg/l or 20% RPD if more than 0.050 mg/l	0.000-0.500
Alkalinity	mg/l CaCO3	-5.0	80-120 % recovery for QC std. and lab fortified matrix	± 2.0 mg/l if less than 20 mg/l or or 20% RPD if more than 20 mg/l	-5.0 to 150.0
Ammonia Nitrogen	mg/l N	.010	80-120 % recovery for QC std. and lab fortified matrix	± 0.01 if less than 0.1 mg/l or 20% RPD if more than 0.1 mg/l	0.00-1.0
Nitrate Nitrogen	mg/l N	.010	80-120 % recovery for QC std. and lab fortified matrix	± 0.02 if less than 0.1 mg/l or 20% RPD if more than 0.1 mg/l	0.00-2.0
Kjehldahl Nitrogen	mg/l N	.025	80-120 % recovery for QC std. and lab fortified matrix	± 0.20 if less than 0.5 mg/l or 20% RPD if more than 0.5 mg/l	0.00-2.0
Secchi disk Transparency	m	0.2	NA	± 0.2 m for duplicate readings by the same monitor, as well as different monitors.	0.0-10.0
Color	PCU	5	80-120 % recovery of color standard	± 10 PCU if less than 50 PCU or 25 % RPD if more than 50 PCU	0-500
Turbidity	NTU	5	90-110% recovery of turbidity std.	± 5 NTU if less than 1 NTU or 20% RPD if more than 1 NTU	0-200
Salinity	SU	0.1	80% -120% recovery of seawater standard of known conductivity	20% RPD	0.0-40.0
Total Suspended Solids, TSS	mg/l	0.01	75-125 % recovery for QC std.	± 1.0 or 25% RPD whichever is higher	0.0-500
Total Dissolved Solids, TDS	mg/l	0.01	75-125 % recovery for QC std.	± 1.0 or 25% RPD whichever is higher	0.0-500
Chlorophyll *a*	µg/l	1.0	75-125 % recovery for QC std.	± 2.0 if less than 15 µg/l or 25% RPD if more than 15 µg/l	0.0-100
Hardness	mg/l	1.0	80-120 % recovery for QC std. and lab fortified matrix	20% RPD	0-100

Indicator	Units	Minimum Detection Limit	Accuracy/Bias[1,2]	Overall Precision[3]	Approx. Potential Range
Fecal Coliform, Enterococcus, E-coli	# of colonies/100 ml	0	"TNTC" on positive control and 0 or less than reporting limit for negative control	30% RPD for log 10 transformed duplicate data	0-100,000
Macrophyte% Cover Map	% area	5	NA (if true % cover were known, results would be expected to be +/- 20%)	NA	0-100%
Macrophyte Identification	NA	NA	Qualitative assessment by aquatic plant experts by spot checking/testing the accuracy of identification using the same plants.	Qualitative assessment based on same-plant identifications by other volunteers in the same group.	NA
Macroinverte-brates (taxonomy)	NA	NA	Qualitative assessment based on spot checks for taxonomic accuracy using the same samples, by macroinvertebrate experts.	Qualitative assessment based on same-sample identification by other volunteer taxonomists in the same group.	NA
Flow (not generally recommended for volunteers to take)	cfs	NA	NA (based on studies using known flows, generally excepted to be 80% - 120% of true flow for scientific staff using best available equipment. For volunteers, the estimated expected accuracy would be reduced significantly (ex. 50-150% or worse)).	35% RPD, based on duplicate flow measurements taken sequentially by two separate volunteers using the same equipment (ex. velocity meter/depth rod, bucket/watch for pipe flows).	0-100 for low flows potentially sampled by volunteers

[1] Accuracy is determined by the analysis of spiked sample except as noted in the table. QC sample recoveries may also be used to assess accuracy when spiked sample analysis is not possible. The general DQO for all analyte blanks is no exceedances of the MDL.

[2] For accuracy determination, spiked samples are preferred

[3] Overall precision is measured using the relative percent difference, RPD (or std. deviation for n>2) of field duplicate samples. Lab precision is based on an estimate of the RPD between duplicate aliquots of the same lab sample. If the same lab sample is split to two or more labs for analysis, a measure of inter-lab precision can be made.

[4] Contact MWWP, MADEP or EPA-NE for additional specific experience.

The use of commercial chemical analysis kits is a special problem because the various data quality limits of the kits are rarely specified in available material. Alternatively, you may choose to use a commercial or professional laboratory for many analyses. The Department of Environmental Protection certifies commercial labs for quality analyses <http://www.mass.gov/dep/bspt/wes/wespubs.htm#certification> (MADEP, 2001), although we caution that this certification is intended solely for the purposes of validating labs that analyze drinking water and wastewater samples and may not be particularly appropriate for most natural waters without first verifying that your data quality objectives are consistent with lab performance. While certification ensures that the lab follows proper quality control procedures, it does not ensure that the lab can meet your data quality requirements, particularly the Method Detection Limit.

Formats To Use

Data quality objectives should be given for each indicator you are measuring, in each "matrix" (i.e., substance you are sampling from, such as water or sediment). The easiest way to present quantitative information is in a table following the form of Table 7.1. Information on completeness, representativeness and comparability is best presented as a narrative.

In some types of monitoring, particularly macroinvertebrate monitoring and habitat assessment, some data quality objectives (especially precision) cannot be quantitatively expressed. In that case, you can simply cite and describe the method used and provide as many of the data quality indicators as possible (e.g., completeness, representativeness, and comparability) in narrative form.

8. Training Requirements / Certification

Identify any specialized training or certification requirements your volunteers will need to successfully complete their tasks. Discuss how you will provide such training, who will be conducting the training, and how you will evaluate volunteer performance.

EPA, 1996

Purpose: To document that volunteers are receiving adequate training from qualified trainers.

What To Include

In this section, you should include the information that describes the training your volunteers will receive:

1. How, when, and by whom your volunteers will be trained to successfully complete each task,
2. the qualifications that trainers will need to carry out the training, and
3. the records you will keep to document the training

Description of Training and Trainer Qualifications

Describe each training and who will carry it out. In Massachusetts, there is a well-developed network of qualified trainers coordinated by the Massachusetts Water Watch Partnership (MWWP) and the Monitoring Support Centers. They can either carry out the training, or train your project coordinator how to do the training. We recommend establishing a formal process of training for volunteers culminating in recognition by the volunteer group of volunteer's capabilities, such as issuance of a certificate. The example on page 28 of the EPA Guide (EPA, 1996) is an acceptable way to describe this process. We recommend that training include site safety and first aid, including CPR.

Keeping Records

You should describe how you will maintain records on who was trained, when training was provided, whether training was passed or certification achieved, and where the records will be maintained.

How to Decide What to Do:

Training is the process of preparing your volunteers to carry out their tasks. All volunteers must be trained.

For each training, we recommend the following process:

1. Background presentation on the monitoring program and how the tasks that the volunteers are being trained to carry out fit into the overall program.
2. Demonstration by the trainer of the task.

3. Practice by the volunteers, closely watched by the trainer.
4. For sample analysis tasks, test the accuracy of volunteers' work with samples of known and unknown concentrations. Test precision with repeated measurements.
5. Give volunteers feedback on their performance at the training session
6. Formally acknowledge successful completion of the training or certify that participants are now qualified to carry out the tasks.

Formats to Use

Tables 8.1 and 8.2 demonstrate possible styles to use.

Table 8.1. Example of Training Program Summary

Task and Type of Volunteer Training	Frequency of Training/Certification and By Whom
Field sampling	Annually, MA Monitoring Support Center* Workshop or by Project Manager
Water chemistry analysis	Annually, Monitoring Support Center* Lab Certification Workshop
Visual observation	Immediately prior to initiation by Project* Manager
Data management	Annually by Monitoring Support Center*
Data interpretation	Annually by Monitoring Support Center* and as needed by TAC

* Monitoring Support Centers are listed in Appendix 1.

Table 8.2. Example of Training Records

Project Function	Training Course Title	Provided by	Training Date	Personnel Trained	Personnel Function	Training Record Location
General Water Quality Field Sampling	Water Quality Field Sampling	MWWP	April, 14, 2000	John Smith	Field Collection Volunteers	Organization office
Lab Analysis	Water Quality Lab Analysis	Project QA Officer	April 20, 2000	Jane Doe	Lab Analysis	Project Headquarters

9. Documentation and Records

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Identify the field and laboratory information and records you need for this project. These records may include raw data, QC checks, field data sheets, laboratory forms, and voucher collections. Include information on how long, and where, records will be maintained. Copies of all forms to be used in the project should be attached to the QAPP.

EPA, 1996

Purpose: To document that your record-keeping procedures will not result in the loss of any data.

What To Include

Samples will travel to various locations from the time of collection through final analysis and archiving. These locations may include the sampling location, perhaps a drop-off point (where all or some of the samples are collected for final transport the lab), the lab where the samples will be analyzed, and perhaps an archive location where preserved samples will be stored. At each location, the samples must be accompanied by some sort of documentation so that the person who receives the samples knows what has happened to the samples. This is particularly true with samples that must be analyzed within a certain period of time. If the lab analyst does not know when the sample was collected, for example, he/she will not know if there is enough time to analyze the sample for valid results.

In this section, you describe the documentation that will accompany your samples from collection through analysis and archiving:

1. **Field data sheets**
2. **Sample labeling**
3. **Chain of custody**
4. **Lab data sheets (including inspection and calibration logs)**
5. **Sample archives and/or voucher collections**

Make sure your description of all the data sheets your project uses contains the information described in these sections. Each of these is briefly described below. We encourage you to use the sample language and formats below to simplify your application process.

1. Field Data Sheets

Field data sheets are completed on-site at the time of sampling. These sheets are provided to each sampling volunteer. There are several types of field sheets:

- **Field sheets that accompany water samples:** At a minimum, these will record the date and time of sample collection, the name and number of the site, site location, type of sample container used, weather and river use observations, air and water temperature, and the sampler's name. Data sheets accompany the samples to the drop-off point, where they are collected by the project coordinator.
- **Field sheets that accompany biological samples:** At a minimum, these will record the date and time of sample collection, number of the site, the number of replicates collected, type of sampler used (e.g. kick net, artificial substrate), site location, where in the water column or on the bottom the sample was collected, weather and river use observations, and the sampler's name. These sheets accompany the samples to the drop-off point, where they are collected by the project coordinator.
- **Field sheets that record field observations or measurements:** At a minimum, these will record the date and time of the observations or measurements, the name and number of the site, site location, observations and measurement results, and the sampler's name. Data sheets accompany the samples to the drop-off point, where they are collected by the project coordinator.

Original field data sheets should be kept at a central location that you name. Sample field sheets may be found at <www.umass.edu/tei.mwwp/acrobat/qapp.html >. They are reproduced in Appendix 3.

2. Sample Labeling

All necessary information must be put on the sample bottle. To make that easier, a sample label, used by MWWP, is shown below (Table 9.1). It is also available in downloadable form at <http://www.umass.edu/tei/mwwp/acrobat/bottle-label.pdf> and is designed to be printed directly on Avery #5163 labels. Labels on bottles should include the site name, date, and any unique sample identification number. Labels must be attached to the container when dry.

Table 9.1. Sample label

Site Location _____
Site No. _____ Sample Type:_____
am
Date: _____ Time: _____pm
mm/dd/yr
Preservation Method: _____
Sampler's Name _____

3. Chain of Custody

Chain of Custody is a procedure for knowing the path that every sample has followed from collection through analysis and data management. While the procedure is more formalized for purposes of litigation, it is encouraged here because it permits an evaluation of performance problems and identification of where additional training may be needed, where equipment may not be working properly or where there has been a communication failure that resulted in something other than desired performance. That is, when a problem with data is discovered, it can be traced back through those people that handled the sample until a possible source of error is discovered. Remediation can then be specifically targeted.

Chain of Custody forms should be signed by collectors as they relinquish their samples at the Drop-off site. Sample ID Number, Date, Time, and Signature of Sample Relinquisher are filled in on the Chain of Custody Form. The person assuming custody must also sign.

The Chain of Custody Form follows the samples to the lab (if different than the drop-off site), where it is signed by the Samples Relinquisher and Receiver. Chain of Custody Forms are copied by the lab and sent to the project coordinator.

A sample Chain of Custody form appears on the following page (Table 9.2).

Table 9.2. Chain of Custody Form

Environmental Analysis Lab. WRRC Univ. of Mass., Amherst, MA 01003-0820 (413) 545-2936

Client: Samplers Signature:_____

Sample ID	Station Location	Date, Time	Type	#Bottles	Analyses	Comments

Relinquished by:Signature	Received by: Signature	Date/Time
Relinquished by:Signature	Received by: Signature	Date/Time
Relinquished by:Signature	Received by: Signature	Date/Time
Relinquished by:Signature	Received @Lab: Signature	Date/Time

Comments:

4. Lab Data Sheets

The lab should use lab data sheets, on which it documents sample processing and analysis. Lab sheets for water and biological samples differ:

- **For water samples:** Record the name of the lab, the analysis date, the time the samples arrived at the lab, the time the samples were analyzed, sample ID # and site #, raw results, calculated results (converted to final reporting units), name of the analyst, and internal QC procedures. Note that some types of analysis will have their own unique information. For bacteria analysis, volume filtered, number of colonies counted, and result in colonies per 100 ml should be recorded. For alkalinity and dissolved oxygen, final concentrations are calculated and recorded.
- **For biological samples:** Record the name of the lab, sample collection date, lab analysis date, site and sample ID #s, the amount of the sample identified, and the numbers of organisms in each taxon. Also record the name of the analysts and the internal QC procedures followed.
- **Equipment maintenance and calibration log:** Keep a log book which lists the dates and type of maintenance for any equipment.

Lab data sheets should be copied and the originals sent to the project coordinator.

Originals of all forms should be maintained in an identified central location accessible to both the project coordinator and quality control officer. Originals should be maintained for several years beyond the project duration. When original documentation can no longer be maintained, they might be provided to a state agency, university or town library wherever agreement can be reached to maintain the original documentation safely but publicly available.

Copies of the documentation and digital databases should be provided to a state, university or town repository as backup. This is an excellent use of the facilities of the Monitoring Support Centers.

5. Sample Archives and/or Voucher Collections

For macroinvertebrates and aquatic plants, a voucher collection should be maintained. This might be of three types:

- Full Archive: All identified specimens are preserved and maintained for verification of identification and/or further taxonomic identification.
- Voucher Specimen Archive: One or more examples of all identified taxa are safely stored for future reference.
- Working Voucher Collection: Clear examples of all taxa to help with training and identification.

Where To Find Forms

Suggested versions of these forms and labels are included in Appendix 3 and are also available for download at <http://www.umass.edu/tei/mwwp/qapp.html>. You may also find suitable templates or forms you can use at your Monitoring Support Center.

Formats To Use

You should narratively describe the paper and computer trail that follows your samples from collection to analysis to storage. State the forms that will be used, who will make entries on the forms and when. For example, "At the time of sampling, the field sampler will fill out the field data sheet and record time of sampling on the Chain of Custody Form, enter the time of sample drop-off and condition of sample (e.g. cold, warm, etc.). Attach all forms that will accompany your samples. If you are using a separate laboratory for analyses, you should include copies of their appropriate forms.

10. Sampling Process Design

Outline the experimental design of the project including information on types of samples required, sampling frequency, sampling period (e.g., season), and how you will select sample sites and identify them over time. Indicate whether any constraints such as weather, seasonal variations, stream flow or site access might affect scheduled activities, and how you will handle those constraints. Include site safety plans. You may cite the sections of your program's SOPs which detail the sampling design of the project, in place of extensive discussion.

EPA, 1996

Purpose: To describe in greater detail the design of the sampling part of your monitoring program.

In Section 6, you briefly outlined the sample process design. In this section, you should elaborate on the rationales for those choices. When you complete this section, you should revisit Section 6 and revise as necessary. The two sections should be in agreement.

What To Include

The parts of this element that must be defined are

- site safety plans
- indicators or measures
- types of samples required
- sampling frequency
- sampling period
- how you will select sample sites and identify them over time

How to Decide What to Do:

As with most study design considerations, there are too many options for us to cover all possible scenarios here. We can offer some general advice, but you should make your decisions in consultation with your Technical Advisory Committee and/or Monitoring Support Center. We encourage you to copy or paraphrase any of the following language in your QAPP.

Site Safety Plans

It is extraordinarily important that the health of volunteers not be endangered in any way. Some organizations and most agencies have liability policies to protect the organization, but what we encourage is the development of plans to protect the volunteers. Volunteers should always leave someone with information about where they will be and when they should return. Volunteers should never sample alone; always have a buddy to help in routine monitoring and take

emergency action in case of an accident. If volunteers have cell phones, they should include them in their monitoring equipment. Make sure that basic first aid equipment is carried by or readily available to volunteers. All volunteers should be instructed in appropriate dress and care in accessing their sampling site. The predominant rule should be that the volunteer's safety is foremost and that sampling should not be attempted if any risk to the volunteer is perceived. . If risky behavior is suspected by any project participant, appropriate steps should be taken to stop that behavior. Sites that have reasonably safe access should be preferred. The project QAPP should outline those measures that are in place to guarantee safety, safety training equipment and procedures.

Following development of a safety plan, the starting point for the determination of other sampling process elements. Beginning with the list of watershed issues developed by your group with assistance from a technical advisory committee, refer to the list of survey types and indicators listed in Section 6 of this guidebook. Pick those most appropriate for your survey. If there are none that match the work you plan, describe your survey in similar terms or describe a new survey type. Consider whether there are any special conditions that require the addition of other indicators. Once you have your list of indicators, you may want to identify them by type: chemical, biological, or physical (see Table 10.1). Then describe the type of samples you will collect. This is largely determined by the equipment available.

Table 10.1. Types of Indicator or Measures.

• Chemical, e.g. pH, total phosphorus, chloride, chlorophyll
• Biological, e.g. benthic invertebrate counts, macrophyte maps
• Physical, e.g. flow, habitat assessments

Following is a list of the types of samples normally collected. You can use these terms to quickly describe the types of samples you plan to collect.

Chemical

- **Grab Samples:** Samples are collected in some type of container by dipping the container in the water and filling it to some pre-determined level.
- **Direct Measurement:** The indicator is measured directly from the water without collecting a sample, e.g. *in situ* measurement of temperature with a thermistor or D.O. and pH with a meter.
- **Multiple Depth Samples:** Individual samples are collected at various depths and analyzed separately.
- **Field Integrated Depth Samples:** Samples are collected from various depths and are combined into one sample for analysis.
- **Field Composite Samples:** Several samples from different locations (or the same location over time) are combined into one sample for analysis.

Biological

- **Qualitative Net Collection**: A sample is collected directly off the bottom using a net. The level of effort is not standardized.
- **Net Collection:** A semi-quantitative sample is collected directly off the bottom using a net. The level of effort is standardized by collecting from a specified area in front of the net. Since the area is not precisely delineated, the method is not strictly quantitative.
- **Rock Baskets:** A quantitative sample is collected by placing rock-filled baskets on the bottom and allowing them to be colonized.
- **Artificial Substrate:** A sampler is placed in the water column or on the bottom and colonized by critters or plants.

Physical

- **Visual estimates** of each of the habitat characteristics, or
- **Field measurements** of each of the habitat characteristics.

Sampling frequency:

The choice of sampling frequency is based on the rate at which change is likely to occur in the measurements. For example, some physical measurements change very slowly and may possibly be measured once a year. Sampling for these may be stretched out over several weeks or months. Biological indicators change with the life span of the organism. For benthic invertebrates, sampling once per year may provide appropriate characterization. Check with experts on the best time to best characterize abundance and diversity for your water body. Sampling should be completed in a relatively short period of time. Aquatic macrophytes in lakes and estuaries have their greatest diversity and abundance in mid to late summer. Algae change daily so all sampling that is meant to characterize conditions at a particular time should be done as quickly as possible. Most investigators recognize that the rapidity of changes in the algae exceeds the ability to sample. Consequently, samples are taken as often as possible depending on the logistical limits with the recognized constraint that not all events may have been completely captured. Weekly to monthly samples are appropriate with loss of resolution as the frequency diminishes. Water chemistry changes the most rapidly, and the same logic prevails as for algae.

Sampling frequency is also dictated by the type of study you propose. Many non-point pollutants are input to water bodies primarily during storm events. If capturing this input is your primary purpose, you should seek the advice of experts in this kind of sampling.

Sampling period:

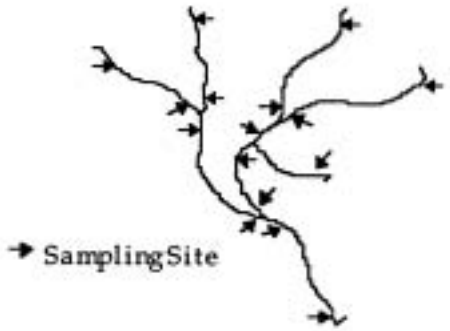
The sampling period is based on two concerns: the ability to characterize significant seasonal changes in the parameter and the safety of collecting samples. Most biological indicators change little during winter months. Chemical activity may also be lessened. Safety of the collectors must be the paramount consideration. However, upon ice out, all begin to change quickly. Spring is often a critical time for rivers, lakes and estuaries, and fall also provides additional information on the functioning of aquatic systems. Summer is, of course, the time when water bodies are most used recreationally by humans.

Time of day sampled:

Certain indicators, like dissolved oxygen and pH vary according to the time of day. In order to understand this daily variability, you may have to sample these indicators at different times of the day, perhaps even hourly over several 24-hour periods. Estuaries are dominated by the tidal cycle which needs to be a primary consideration in sampling time; some rivers are extensively controlled for flow so similar consideration is important. For others, like benthic macroinvertebrates, the time of day is not important.

Sample site selection:

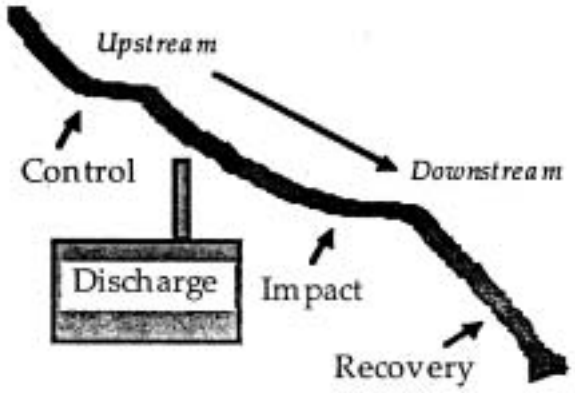
- In ***rivers***, there are basically two approaches to selecting sampling sites. Either you are trying to characterize a particular portion of the river in a representative way or you are trying to demonstrate the impact of a suspected pollution source on a specific part of the river. To locate test sites for characterizing a river, the best approach is to divide the river into relatively homogenous reaches (e.g. gradient, geology, land use, etc.) between tributary confluences. Enough sites should be selected to represent all of the typical conditions in your water body. The sampling site might be anywhere in the reach but typically a site somewhat upstream of a road crossing or access point is chosen.



from VEMN Study Design Workbook

For an impact assessment, the standard approach is to pick one site upstream of the potential pollution source (the reference or "control" site) and one or several sites ("impact" and "recovery" sites) downstream.

- **Upstream Reference (Control) Sites:** These sites are upstream of some sort of human alteration of the stream. They represent conditions in the stream prior to the impact of the alteration.
- **Impact Sites:** These sites are downstream of some sort of human alteration of the stream. They represent conditions in the stream after the impact of the alteration.
- **Recovery Sites:** These sites are downstream of some sort of human alteration of the stream. They represent conditions in the stream after the impacts of the alteration have begun to diminish. You should describe in narrative form why this site is not complicated by other possible impacts but is far enough away to allow recovery.



from VEMN Study Design Workbook

These two sampling strategies may be mixed to yield both general characterization of the river and specific information about potential pollution sources.

In ***lakes***, the same two strategies prevail. The general characterization might be at just one site, usually at mid-lake or over the deepest part of the lake, or it might be several sites in the middle of coves and bays if the lake is irregular in shape. Adding sites specific to potential pollution problems provides the equivalent of the upstream/downstream strategy for rivers. These additional sites might be near-shore or at the mouths of inlets depending on the suspected pathway of pollutants. Following are some different types of lake assessment sites that account for the horizontal and vertical variations.

You can use the following types of sites to quickly describe each of the sites you choose.

- **Deepest Sites:** The water in the deepest places in the main lake and in embayments tends to be the most representative of conditions in the lake. At these sites, you need to decide at what depth(s) you will take samples in order to assess the condition of different layers.
- **Mouths of Tributaries (Inlets):** These represent the condition of the tributary before it enters the lake and integrate conditions occurring upstream.
- **Lake Outlet:** These sites are where the lake spills over a dam or enters a stream. They represent the conditions of the water as it leaves the lake.
- **Water Use Sites:** These are sites where various types of human water use occur, such as swimming areas (formal and informal), boat launch areas, fishing access areas, and water supply intakes. The idea is to assess conditions that affect these uses at these sites.

Estuaries may use a combination of lake and river strategies.

For all three, the use of sites selected by state or federal monitors will provide sites with historical information, probable importance to state water quality goals, and comparability with data collected by professionals.

Site access should be one of the first considerations taken in your project. You must have permission to access the water body if traversing private property is required. The best approach is to make an appointment with the property owner in advance, describe your purpose and ask for signed permission. While generally there is no problem, access may be denied if the property owner suspects that you will be describing a problem that he/she will have to pay to solve. In rivers, physical characteristics can also limit access; safety is paramount in all cases.

Over time, you will add sample sites as your program evolves and you might eliminate sites that don't yield useful information. Describe how you will do this.

When you have completed your assessment of the types, location, and frequency of sampling, conduct a reality check against what is feasible in manpower and cost for the members of your organization. Adjust your sampling design accordingly. Remember that the sampling process design must be feasible for the long-term and under a variety of adverse conditions.

Where To Get the Information

Your most valuable resource in assembling the information nccessary to select an appropriate sampling process will be local experts and agencies. You should try to have some of these on your technical advisory committee but seek others out as the needs demand. Be sure that they have as much information on the watershed as possible and the issues and priorities that you selected in Element 5.

A tool that you and your experts may find valuable tool in selecting sampling sites is the MassGIS Watershed Analyst <http://www.state.ma.us/mgis/>. It permits examination of map-based and tabular watershed information within a visual context of likely water pathways. For example, potential pollution sources may be located on the watershed map and the probable path of pollutants traced through the waterways. Sampling sites may be located to characterize water quality above and below the potential source. Similarly tributaries and roadways are shown and sites can be selected that are representative and easy to access. Since this tool requires significant computer expertise, consult with your Monitoring Support Center about its availability.

Formats To Use

Summarize your decisions either in narrative, map, or table form.

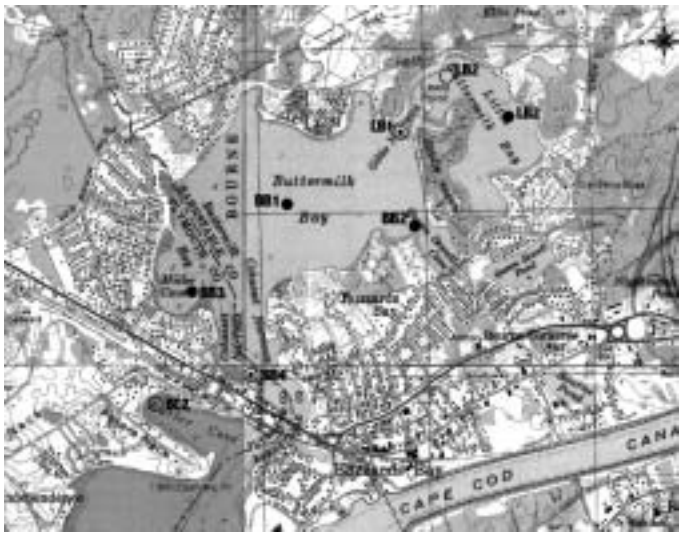
Sampling Frequency, Period, and Time of Day and Location

For simple sampling strategies, a narrative works well. If you are sampling many different indicators with different sampling methods, a table like the one below (Table 10.2) is best.

Table 10.2. Example of a Table of Sampling Frequency, Period and Time of Day

Measure(s) or Indicator(s)	Sites	Brief Description of Location	Type of Site	Frequency	Type of Sample Collected	Time of Day Sampled	Special Weather Conditions
pH, alkalinity, DO	#25	100 yards upstream of Rte. 15 crossing (town)	Control	Semi-monthly from June-September	Water: grab sample Benthics: grab sample before leaf fall.	6-8 a.m,	None
Benthic macroinvert-ebrates	#25	Nearest riffle to chemical site #25	Control	Once in April Once in September	Water: grab sample at surface Benthics: grab sample before leaf fall.	N/A	Avoid high flows

A map is the best way to show the location of the sampling sites and the potential source of pollution, the latter from your preliminary watershed assessment. Site maps should be 8 1/2 x 11" but larger, fold-out maps and drawings may be included. An example map is shown below (Howes et al. 1999).



11. Sampling Method Requirements

Describe your sampling methods. Include information on parameters to be sampled, how samples will be taken, equipment and containers used, sample preservation methods used, and holding times (time between taking samples and analyzing them). If samples are composited (i.e., mixed), describe how this will be done. Describe procedures for decontamination and equipment-cleaning. (For example, kick nets need to be thoroughly rinsed and examined for clinging organisms between sampling events.) Most of this information can be presented in a table or you may also cite any SOPs that contain this information. *EPA, 1996*

Purpose: To describe your sampling methods.

What To Include:

You should list all the parameters you will sample, what medium (water, sediment, etc.) you are collecting each parameter from and the following information about the methods you will use to collect samples.

Sampling containers or devices/ preservation: What type of container or devices will be used? Will the sample be preserved and, if so, how? See Table 11.1 for guidance on appropriate containers and preservation.

Minimum quantity of sample to be collected: How much of the sample will be collected? This is determined by the needs of your analytical method. See Table 11.1 for guidance on appropriate quantities.

Methods Reference: Cite a specific method and the source. For example, a bacterial sampling method might be described as "grab sample per Standard Methods 9060," but any variations should be completely described in your SOP and accompany the generic description. Use the lists below for terms that describe your sampling method. Be sure to define them in your QAPP.

Maximum Holding Time: How long samples will be held before lab analysis? Some indicators change over time, even in a matter of hours. For example, bacteria reproduce and die in the sample, changing the number of cells that will grow for the analysis. The maximum holding time is the maximum time between taking samples and analyzing them that will produce acceptable results.

Standard Operating Procedures (SOPs): A complete set of all your field SOPs should accompany your QAPP. You may use SOPs that have been approved for other projects but be sure to indicate any differences that you may have adopted. Simply citing another's SOP will not be sufficient.

In the table below (Table 11.1), we have compiled information on US EPA acceptable water sample sizes, containers, preservation and holding times. Variations from these may be acceptable if accompanied by a citation of the published literature source. These guidelines should be rigorously followed with the following exceptions:

- There is no danger in exceeding the minimum sampling size for most indicators (for example, the nature of the collection bottle for Dissolved Oxygen precludes this),
- When possible, it is almost always better not to preserve samples if you can meet the non-preserved holding time. The cited holding time is the maximum allowed, so shorter times are always to be preferred.

Table 11.1. Container, Sample Size, Type, Preservation and Storage for Common Water Quality Indicators (Standard Methods 20th edition, 1998)

Indicator	Container Type[1]	Minimum Sample Quantity (ml)[2]	Sample Type[3]	Preservation	Maximum Holding Time
Fecal Coliforms	Sterile P, G bottles or Whirl-Pak Plastic Bags	>100 ml	g	Refrigerate, 4°C See delayed incubation procedure 9222E in Standard Methods	Refrigerate immediately. Deliver to lab within 6 hr. Begin analysis within 2 hr. of receipt.
Alkalinity	P, G	200	g	Refrigerate, 4°C ,do not open sample bottle until analysis	14 days
BOD	P, G	2 bottles 300, 60	g, c	Refrigerate, 4°C	48 hrs
Chlorophyll	P, G	1000	g	Unfiltered, dark, 4°C	Unfiltered, fresh-24 hr;[4] Filtered, frozen-21 days;[4] Filtered, forced air-dried-15 days[5]
Specific Conductance	P, G	500	g, c	Immediately or refrigerate at 4°C, filtered with 0.45 micron filter	28 days
Ammonia	P, G	500	g, c	Refrigerate to 4°C add H_2SO_4 to pH<2 and refrigerate	48 hours 28 days
Nitrate	P, G	100	g, c	Analyze as soon as possible; refrigerate, 4°C add H_2SO_4 to pH<2 and refrigerate	48 hr 28 days
Organic, Kjeldahl	P, G	500	g, c	Add H_2SO_4 to pH<2. Refrigerate, 4°C,	28 days

Indicator	Container Type[1]	Minimum Sample Quantity (ml)[2]	Sample Type[3]	Preservation	Maximum Holding Time
Oxygen, dissolved Electrode Winkler	 G, BOD bottle	 300, 60	g	 Analyze immediately Titration may be delayed after fixing	 Analyze immediately 8 hr in the dark
pH	P, G	50	g	Analyze immediately	Analyze immediately
Phosphorus, total	P, G Acid-washed; no use of detergent permitted	100	g, c	Immediately Add H_2SO_4 to pH<2 and refrigerate at 4°C Freeze	48 hrs 28 days 12 months
Salinity	G, wax seal	240	g	Analyze immediately or refrigerate at 4°C	28 days
Temperature	P, G	-	g	Analyze immediately	Analyse immediately
Turbidity	P, G	100	g, c	Cool at 4°C	48 hr
Total Suspended Solids Total Residue/ Total Solids, Dissolved Solids	P, G	500	g	Immediately or refrigerate to 4°C	7 days

1 Container — P = polyethylene or equivalent; G = glass
2 Minimum Sample Quantity – plan at least two minimum sample quantities for reanalysis contingencies
3 Sample Type — g = grab; c = composite
4 Published in EPA Methods (1999) or Standard Methods (AWWA,1998)
5 Recent modification in the peer reviewed literature. (Godfrey & Kerr, 2000)

This table should not only help in responding to the QAPP requirement for sample method requirements but aid in the purchase of materials for sampling and arrangements with support labs. As part of general volunteer training, sampling methods should be explained and written instructions provided to all volunteers.

Formats To Use

Most of this information can be presented in a table like the one below (Table 11.2). You must attach a detailed Standard Operating Procedure (SOP) that contains step by step descriptions of sampling and analysis procedures. The SOP must describe your actual practice, not a generic practice, but you can provide the generic description and carefully detail your specific differences in a table or an accompanying narrative. Your group may have developed your own SOPs or you may follow those of the Massachusetts Water Watch Partnership. The latter may be found at <http://www.umass.edu/tei/mwwp/sop.html>. Appropriate Standard Operating

Procedures for field and lab may be downloaded, printed and included as appendices to the QAPP, but they must be accompanied with a description of any procedures that you routinely use that are exceptions to these generic procedures. Your SOP should either include a description of preservation and holding times or refer to a table in your QAPP.

Table 11.2. Example Table of Sampling Methods.

Indicator	What Will Be Sampled	Sampling Equipment	Sampling Method
Dissolved Oxygen (lake)	Water	Modified Wisconsin Sampler w/ 60 ml BOD bottle	Sample collected 0.5 m from lake bottom and fixed on site
Dissolved Oxygen (river)	Water	BOD bottle (300 ml)	Sample collected at surface with care to avoid any bubbles and fixed on site
Total Phosphorus	Water	1 liter acid-washed polyethylene bottle	Bottle rinsed 3 times with water at site and filled at elbow depth by inserting bottle, mouth down, to depth and inverting. Sample is fixed with sulfuric acid.
Benthic Macroinvertebrates	Riffle Bottom	8 X 18 metal frame nets with 500-6 micron mesh and 1 liter wide-mouth Nalgene bottles.	3 composite samples (each consisting of collection from 2 fast and two slow sections in the riffle) are collected and preserved in 90% ethyl alcohol

12. Sample Handling and Custody Requirements

Sample handling procedures apply to projects that bring samples from the field to the lab for analysis, identification, or storage. These samples should be properly labeled in the field. At a minimum, the sample identification label should include sample location, sample number, date and time of collection, sample type, sampler's name, and method used to preserve sample. Describe the procedures used to keep track of samples that will be delivered or shipped to a laboratory for analysis. Include any chain-of-custody forms and written procedures field crews and lab personnel should follow when collecting, transferring, storing, analyzing, and disposing of samples.

EPA, 1996

Purpose: To demonstrate that your sampling handling and storage techniques will retain/safeguard the integrity of your samples and data records.

What To Include:

Samples will travel to various locations from the time of collection through final analysis. These locations may include the sampling location, perhaps a drop-off point (where all or some of the samples are collected for final transport the lab), the lab where the samples will be analyzed, and perhaps an archive location where preserved samples will be stored. Close coordination with the project lab will be necessary to complete this section.

There are five steps to sample handling and custody. Describe how you will carry out each step.

1. **Sample labeling:** The description of this part should state that the label will be attached to dry bottles. Information on site location, site ID#, sample type, date and time, preservation (if any), and the name of the sampler will be added in permanent marker at the time the sample is collected.
2. **Completion of field data sheets:** Field sheets should be completed at the site when the sample is collected. However, some information (such as elevation or latitude and longitude) may be filled in later. Field samplers should be advised to review any readings they take in the context of expected measurement ranges stipulated in section 7 of your QAPP. For instance, a river monitoring program may warn samplers to watch for water temperature readings below 0C or above 30C, for DO meter readings below 4 or above 14. Any time a sampler records a reading outside of the expected range or that is suspect for any other reason (e.g. one site is much higher than the rest), the sampler must:
    - Do what's possible to verify/fix before leaving the site: e.g. take another reading, check equipment, etc.
    - Report to appropriate supervisor (i.e. field leader or project leader) immediately. The supervisor should discuss the situation with the sampler and decide whether to make a site visit to resample (perhaps using different equipment – e.g. a substitute DO meter or with a Winkler titration kit).

3. **Sample transport and chain of custody:** Samples may be transported from the field to a drop off point or lab. Your QAPP should describe how that will happen. For example, samples which must be kept cool and dark will be transported in coolers will be transported to the lab within 2 hours of collection. A chain of custody form is not mandatory, but is recommended. If used, it must accompany all samples at every step. Its purpose is to document each person responsible for the sample at each stage from collection to analysis. It can often be very helpful in trying to solve later uncertainties about results because, although the sample bottle contains some of this information, it will be relabeled and reused soon after a sample is collected. The chain of custody form is the lasting record for the sample handling information. The collector should complete initial parts of this form when the samples are collected. If a Chain of Custody Form is not used, field and lab sheets should clearly list who handled the sample at each step. See section 9 for an example of a chain of custody form.
4. **Sample disposal:** Once the analysis is run, what will you do with the left over sample and processed sample? Water samples usually cannot be stored for further analysis and must be disposed of properly. Some processed sample contain hazardous waste which must be handled according to strict guidelines at the lab. For example, bacteria plates must be sterilized at the end of the process to kill any pathogens. The sample processes and analyses for nitrates contains cadmium, a hazardous material. Your lab should have SOPs which cover the proper disposal of these materials.
5. **Sample storage:** Some samples can be stored for later, repeated, or further analysis. Describe how and where these samples will be preserved and stored for the long term.

Proper labeling and documentation of each of these steps is covered in section 9,

Formats To Use

This section can be done in narrative form for each type of sample.

13. Analytical Methods Requirements

List the analytical methods and equipment needed for the analysis of each parameter, either in the field or the lab. If your program uses standard methods, cite these. If your program's methods differ from the standard or are not readily available in a standard reference, describe the analytical methods or cite and attach the program's SOPs.

EPA, 1996

Purpose: To document that your sample analysis methods will yield results that are within your data quality objectives.

What To Include:

To complete this section, you must decide how you are going to analyze your samples. Some samples may be analyzed in the field using a meter. Others will be transported to a lab for analysis there.

Analytical methods describe the specific step-by-step procedures that will be used to determine the amount of a particular indicator in the sample. Two common sources for rigorous methods are *Standard Methods for the Examination of Water and Wastewater* ("Standard Methods" for short; AWWA, 1998) and an extensive series of publications from EPA known as 40 CFR 136.3 that is mostly compiled on one CD *EPA Methods and Guidance for Analysis of Water* ("EPA methods" for short; U.S. EPA, 1999). Beyond these, there are many adaptations developed by agencies, companies that sell equipment, etc.

We suggest including the following information for each sample or sample type:

- **Indicator**: For what indicators will the sample be analyzed?
- **Method Number**: This is a reference number that will guide the reader to a specific analytical method.
- **Source**: Where the method comes from (for example *Standard Methods)*
- **Modifications:** Describe any modifications you have made to the method and the rationale.
- **Reporting Units**: In what units will the results be reported? For example, mg/L, NTUs, number in each taxon, etc.
- **Standard Operating Procedures (SOPs):** A complete set of all your analytical SOPs should accompany your QAPP. You may use SOPs that have been approved for other projects but be sure to indicate any differences that you may have adopted. Simply citing another's SOP will not be sufficient.

How To Decide On A Method

EPA and Standard Methods provide the standard against which others should be compared. "Kits" and other equipment and methods from companies such as Hach, Inc. and LaMotte, Inc. may meet all the requirements of the normally accepted methods; they may also be easier,

cheaper, and have fewer laboratory support requirements. Determining which will meet analytical criteria to meet your data quality objectives is a difficult task. Equipment manufacturer's advertising material often does not contain appropriate information for rational choice. We strongly encourage you to consult with your Monitoring Support Center (see Appendix 1) before committing to methods, instruments or kits that are not listed in this guidebook.

Here are some things to consider in choosing a method:

Scientific Considerations:

- Does it meet your data quality objectives?
  - How accurate is it?
  - How precise (reproducible) is it?
  - What is its detection limit?
- Will it measure the indicator in the range that you need?
- What lab facilities are required?
- What equipment is required?
- Does it yield samples that are representative?
- Is it comparable to methods used by agencies collecting similar information?

Practical and Program Considerations:

- Do you have the human and financial resources to do it?
- How difficult is it?
- How time-consuming is it?
- Will it produce data useful to the target audience?

If you are considering the use of various monitoring kits or probes from Hach, LaMotte, YSI and others, you should take great care to determine if the kits or probes will meet your data quality objectives. You might want to construct a worksheet as shown below (Table 13.1) to help collect the key information and guide your decision process. You should refresh your memory of the meaning of these DQOs by re-reading section 7, particularly the difference between instrument detection limits and method detection limits or practical quantitation limits.

Table 13.1. Sample worksheet to aid in selecting kits or probes.

Parameter (e.g. Total Phosphorus)

Objective, Method or Supplier	**Minimum Detection Limit (MDL or RDL)** [3]	**Range** [3]	**Precision**[3]	**Accuracy**[2]	**DQO match**
Your Data Quality Objective[2]	**0.010 mg/l**	**0.010-0.500 mg/l**	**0.010 or 20%**	**0.010 or 20%**	
EPA or Standard Methods[1]	0.005 mg/l	0.005-1.0 mg/l	0.010 or 20% RPD	0.010 or 20% RPD	Equal or Better
Hach[1]	0.020 mg/l	0.020-1 mg/l	?	?	No
LaMotte DC1200-PLR[1]	0.070 mg/l	0.070-3.0 mg/l	?	?	No

1 From the method description or SOP.

2 From your Data Quality Objectives.

3 Pay careful attention to the number of significant figures in the information provided by equipment providers. For example, zero expressed as 0 means any value between -0.5 and 0.5; 0.0 means any value between -0.05 and 0.05; 0.000 means any value between -0.0005 and 0.0005. The number of significant figures should match your data quality objectives. Insist on more detailed QA/QC information from any provider that does not match your data quality objectives in their catalogs.

Inclusion of the trade names does not constitute endorsement by the authors, the University of Massachusetts, Commonwealth of Massachusetts or United States Government nor does it imply a comprehensive list of providers.

We are not disparaging the use of these kits because many of them are equivalent or nearly equivalent substitutes for the purpose: less expensive, simpler, or safer. . If your purpose is largely educational, the kits may be the most appropriate analytical methods because participants experience the full range of hands-on involvement with a minimum of technical training, as long as the kits meet your data quality objectives. For many kits or probes, such as D.O. probes, nitrate probes, alkalinity titrations, and temperature, the best techniques may be kits or instruments from these companies. However, unless they appear on the EPA-approved list, the acceptability by EPA and state agencies may be limited. A current list of EPA approved kits or techniques may be found at <http://www.umass.edu/tei/mwwp/acrobat/kits.PDF>. Appropriate data from the kit manufacturers that would allow comparing standard methods with the kit performance are usually not readily available to the consumer. If you use a kit or probe that is not accepted by EPA, seek help and advice from your technical advisory committee, Monitoring Support Center, agencies and other experts before purchasing the equipment. In trying to make a wise decision on methods and equipment to use, your data quality objectives are your principal consideration, along with your capabilities. If you have independently decided that appropriate measures require specific levels of detection and range of measurement, precision and accuracy, your choice of methods and equipment must be consistent. Selecting equipment that cannot meet your goals automatically and negatively changes your goals, your potential users and major elements of your program.

Even the use of standard sampling and analytical methods, assuming quality control objectives are comparable and are achieved, may not permit comparison with other monitoring efforts. Use of different approved methods may require that a limited comparison of both methods be made. For example, a volunteer group may use the Multiple Tube Fermentation for fecal coliform while the state uses the Membrane Filtration procedure. Perhaps, the volunteer group uses the forced air-drying method for chlorophyll but the state doesn't. The volunteer group may use a double-end point titration for alkalinity whereas the accepted methods are for single end-point titrations even though they are less appropriate for New England. Or, for logistical reasons, an analysis such as pH or bacteria can not be done within the prescribed holding time. We strongly encourage that you work with your Monitoring Support Center and your identified QA reviewers to determine if acceptable modifications can be developed.

Formats To Use

If you are using standard methods, the information available at <http://www.umass.edu/tei/mwwp/sop.html> will be helpful. You should construct a table showing the parameter, literature source and method number. If there are modifications or important options, these should be listed. An example is given below (Table 13.2).

Table 13.2. Example of a Sample Methods Table

Indicator	Method Number	Source	Reporting Units	Modifications or options
Chlorophyll a	10200 H	Standard Methods, 20th ed.	µg/L	air-dried filters - Whatman GF/F, holding time - 15 days, 5 cm spectrophotometer cell chlorophyll/ pheophytin
Dissolved Oxygen	4500-O C	Standard Methods, 20th ed.	mg/l	Hach digital titrator Hach powder pillows
Total Phosphorus	Model AM-02	LaMotte	mg/l	Comparator test (MDL 0.2 ppm)

Much of this information may be contained in a separate Quality Assurance Plan (QAP) for the laboratory that you are using. It may be cited with appropriate sections or pages identified.

If you are planning to use a kit or non-standard method, a full description of the method should be attached, in addition to listing the kit provider or source of the method and the model number of the kit. We encourage you to obtain as much information as possible before purchasing kits or *in situ* measuring equipment and to compare that information with the standard methods. Seek additional help from your Monitoring Support Center and Technical Advisory Committee. The Water Watch Partnership web page will develop a list of kits that have passed muster as volunteer monitoring experience increases.

14. Quality Control Requirements

List the number and types of field and laboratory quality control samples your volunteers will take. (See Chapter 3 for a discussion of quality control samples.) This information can be presented in a table. If you use an outside laboratory, cite or attach the lab's QA/QC plan.

QC checks for biological monitoring programs can be described narratively, and, if appropriate, should include discussion of replicate sample collection, cross checks by different field crews, periodic sorting checks of lab samples, and maintenance of voucher and reference collections. Describe what actions you will take if the QC samples reveal a sampling or analytical problem.

EPA, 1996

Purpose: To document that the specific quality control measures you will take will allow you to determine whether you meet your data quality objectives.

What To Include

In section 7, we described the basic concepts of accuracy, precision, and other measures of data quality. In this section, we describe how to test these measures to see whether you meet your data quality goals.

In your QAPP, include the following information:

1. **Indicator**: List each indicator you will monitor
2. **Accuracy Checks**: For each indicator, list the accuracy checks you will perform (see below for a list of these). Not all indicators have an appropriate accuracy check as indicated in Table 14.1.
3. **Precision Checks:** For each indicator, list the precision checks you will perform (see below for a list of these).
4. **% Quality Control Samples:** List the percent of your samples upon which you will perform quality checks that will represent the quality of all your samples.

How You Will Decide What to Do:

Lab analysts should examine all their results for values that fall outside the possible range: any "suspect" analyses should be checked with a supervisor (i.e. whoever is listed on the chain of command chart you created in section 4) and re-run the analysis, if possible, or arrange for resampling.

Other quality control checks are described below. These represent the suite of tools available. Not all are appropriate for each indicator. Table 14.1 indicates which should be used for each indicator.

Accuracy Checks

There are a variety of ways to check the accuracy of your sampling and analysis. These checks can be done internally (done totally within your project lab) or externally (done with the assistance of an independent lab).

- **Known Samples:** This is an internal check that compares your results against another analyst or a "known."
- **Proficiency Testing (Unknown) Samples:** In some cases, there are programs that provide proficiency testing samples for laboratory performance evaluation, the concentrations of which are known to the auditor but not to the lab being tested. This is relatively common for most water chemistry indicators. A current list is maintained by National Voluntary Laboratory Accreditation Program (NVLAP) <http://ts.nist.gov/ts/htdocs/210/214/scopes/calchem.htm>. Some laboratories providing bacterial proficiency testing samples are listed in Appendix 1. For some indicators, water chemistry and biology, the only available means of checking accuracy is to compare results with another lab or with a taxonomic expert.
- **Field Blanks:** Water chemistry samples should also be evaluated for possible contamination during collection. Known as a field blank, this is customarily done by filling a sample container in the field with de-ionized water as if it were a river or lake sample (other types of field blanks may be employed to resolve specific problems; consult your Technical Advisory Committee or Monitoring Support Center). It is suggested that ten percent of all samples collected in the field (minimum of one per sampling) should be field blanks. Field blanks should be evenly distributed over all sampling sites, sampling dates and parameters. This is an internal check.
- **Blank and Positive Plates:** Bacteriological samples should be checked using the blank and positive plate procedure. The blank plate uses the rinse water, media and equipment in the analysis to determines if there is contamination in the laboratory materials. The result should be "0." The positive plate procedure uses a sample known to contain bacteria (e.g. waste-water treatment plant influent) to determine if a procedural error in the lab causes inhibition of bacterial growth. Results should be "too numerous to count." Each batch of samples should include at least one blank and one positive check sample. This is an internal check.
- **Spiked Samples:** Spikes are additions of a known amount of the indicator with the expectation that subsequent analysis will measure exactly that much increase over the un-spiked sample. This procedure will also be familiar to certified labs and is also described in Section 1020 B of Standard Methods. This is an internal check.
- **Voucher and Reference Collections:** For macroinvertebrates and aquatic weeds, maintenance of a voucher collection and a working reference collection is highly recommended. A voucher collection is essentially a preserved collection of the "type" specimens, that is an example of each of the individual types that you have given a name. It should be maintained in archival condition by a trained curator, typically found at a university. A reference collection is an exact duplicate of the voucher collection but is the one that you will regularly use as a reference when identifying new specimens. Both voucher and reference collections should be verified by an expert. This is an external check.

Precision Checks:

Precision checks are primarily accomplished through replicate sampling and analysis in the field and lab.

- **Field Replication:** Starting with the information already developed on the number of sampling sites, sampling frequency, and indicators, you can develop your quality control requirements for replication. As a general rule, at least 10% of all samples collected should be replicated. That is a relatively acceptable performance standard for water chemistry, but biological samples are much more variable. For chlorophyll, consider 20% replication. For macroinvertebrates and aquatic weeds, where subtle habitat differences are important, consider the need for replicates or triplicates for all samples collected. Procedures for macroinvertebrates are detailed by Barbour et al. (1999). You should also try to control as much as possible for changes in habitat, i.e. collect replicates from habitat that appears in every way the same. Replication can be done by the same field collectors but your QAPP should provide for some replication by other collectors. This might be as simple as a pair of field collectors swapping roles or more complex if a different team collects the replicate. The best guideline is to keep replication a relatively simple process and only use the more complex measures when unexplained problems are noticed by the Quality Control Officer. Discussion of this topic occurs in sections 22 and 23. This is an internal check.
- **Lab Replication:** In addition to this level of field replication, additional replication should occur in the lab. Lab replication is done by dividing a well-mixed sample into two or more aliquots and conducting analysis on each aliquot. Ten percent replication is the norm. That is, 10% of all samples received by the lab should be analyzed at least twice. Again, this replication should be evenly distributed over all sampling sites, sampling dates and parameters. This is an internal check.
- **Split Samples:** A split sample is a sample that is split into two sub-samples at the lab or in the field. One sub-sample is analyzed at the project lab and the other is analyzed at the independent lab and the results compared. This external check is used to estimate inter-laboratory analysis precision. When analysis is customarily conducted in the field, a useful check is to have the sample analyzed in the laboratory. This is useful in estimating field analysis precision.
- **Control Charts:** Many chemical sampling analyses are amenable to the use of control charts as means to manage lab performance. Control charts are based on specifying acceptability limits for precise measurement of an internal lab standard. The procedure will be familiar to certified labs and is described in Section 1020 B of Standard Methods. You may wish to request copies of control charts from your certified laboratory to include with your data quality documentation.

More detailed information on quality assurance measures can be found in Chapter IV of the VEMN Guide to Volunteer Watershed Monitoring Options in the Merrimack River Watershed. It is available at <http://www.umass.edu/tei/mwwp/qapp.html>.

The table below (Table 14.1) recommends specific quality checks for selected indicators. You can use this table to select checks for your program.

Table 14.1. Recommended Quality Control Checks for Accuracy and Precision

Indicator	Accuracy	Precision
Fecal Coliform E. coli	Negative and positive plates	Field and Lab replicate analysis
Dissolved Oxygen	Use MWWP audit sample	Field and Lab replicate analysis
Turbidity	Use QC std./audit sample	Field and Lab replicate analysis
Secchi Transparency	Annual calibration check of calibrated line	Field replicates by different observers
Temperature	Compare with NIST-certified precision thermometer	Field replicate observations by different observers
pH	Use MWWP or commercial audit samples	Field and Lab replicates
Total Alkalinity	Use MWWP or commercial audit samples, blanks, standards	Field and Lab replicates
Conductivity	Field blanks	Field and Lab replicates
Total Phosphorus	Use commercial audit samples including dilutions to MA relevant levels Spiked sample recovery Field blanks	Field and Lab replicates
Nitrogen -Total Kjehldahl	Use commercial audit samples including dilutions to MA relevant levels Spiked sample recovery Field blanks	Field and Lab replicates
Nitrogen - Nitrate	Use commercial audit samples including dilutions to MA relevant levels Spiked sample recovery Field blanks	Field and Lab replicates
Nitrate - Ammonia	Use commercial audit samples including dilutions to MA relevant levels Spiked sample recovery Field blanks	Field and Lab replicates
Biological Oxygen Demand	Use commercial check standard or use the glucose & glutamic acid solution described in Standard Methods, 20th ed., method 5210 B.	Field replicates

Indicator	Accuracy	Precision
Chlorophyll a	Partial accuracy check using commercial audit samples	Field and Lab replicates
Total & Total Dissolved Solids	N/A	Replicates
Macrophyte taxa	Expert verification	Replicates
Macrophyte distribution	N/A	Limited area replicate observations by different observers
Macrophyte % cover	N/A	Limited area replicate observations by different observers
Macroinvertebrate taxa	Expert verification	Replicates
Macroinvertebrate abundance	N/A	Replicates
Habitat	N/A	Replicates
Flow	Comparison to volumetric (eg. bucket) or discharge devices (flume) at the same location	Replicates

N/A = Not applicable because knowns are not available for testing

Formats To Use:

Your quality control measures can either be described in narrative form for a program monitoring only a few indicators, or using a table format similar to Table 14.2 for programs monitoring many indicators.:

Table 14.2. Sample Table: Quality Control Checks

Indicator(s)	Accuracy Checks	Precision Checks	% Quality Control Samples
Temperature	Compare with NIST-certified precision thermometer	Field replicate observations by different observers	10%
Dissolved Oxygen	MWWP Audit Sample	Field and Lab replicate analysis	10%
Benthic Macroinvertebrates	Taxonomic verification.	3 Replicates at each site	All

15. Instrument/Equipment Testing, Inspection, and Maintenance Requirements

Describe your plan for routine inspection and preventive maintenance of field and lab equipment and facilities. Identify what equipment will be routinely inspected, and what spare parts and replacement equipment will be on hand to keep field and lab operations running smoothly. Include an equipment maintenance schedule, if appropriate.

EPA, 1996

Purpose: To demonstrate that your equipment and lab facilities will be maintained in a way that will not compromise the quality of your sampling, analysis and recordkeeping work.

What To Include:

Regular inspection of your equipment will help guarantee that sampling will not encounter insurmountable difficulties. We strongly urge the development of a pre-sampling checklist of equipment and supplies that need to be checked and another checklist of equipment and supplies that should be brought into the field by the collector. The first items on the field collection list should be safety equipment. As a general rule of thumb, the more complicated the equipment, the more likely it will fail at an inopportune time unless you inspect and prepare for any eventuality. Your procedures for this process must be described in your QAPP.

Include the following information in this section.

1. **Equipment Type:** List the equipment you will be using
2. **Inspection Frequency:** How frequently will you inspect each item?
3. **Type of Inspection:** Describe the nature of the inspection your will do.
4. **Available Parts:** What spare parts will you keep on hand?
5. **Maintenance:** How often will maintenance be carried out and how will it be recorded.? Where will the equipment be stored?
6. **Recordkeeping:** What records are kept on equipment care and repair, etc.? Where are records kept?

How To Decide What To Do:

We suggest that you create and maintain a logbook that records equipment checks, repairs, calibration, part replacement, etc.

We offer the list below (Table 15.1) as a starting point for your equipment inspection and maintenance requirements. Use this to develop your own narrative or table. Corrective action may be described in the owner's manual or may need consultation with your manufacturer's representative, Technical Advisory Committee or Monitoring Support Center.

Table 15.1. Recommended Equipment Inspection and Maintenance. Maintenance and corrective action procedures should be described in your QAPP. These will either be part of the method description or manufacturer's recommendations.

Equipment Type	Inspection Frequency	Type of Inspection	Available Parts	Maintenance, Corrective Action & Recordkeeping
Wisconsin Sampler	Before each sampling date	No leaks Proper operation of trip mechanism	Spare sampler	Annually or as needed Logbook notation
Secchi Disk	Before each sampling date	Visual	Spare disk	
Calibrated Line	Before each sampling date	Integrity of line and clips		Annually or as needed Logbook notation
D.O. Meter	Before each sampling date	Battery life, electrical connections, membrane condition	Spare membranes, batteries	Annually or as needed Logbook notation
Thermistor	Before each sampling date	Battery life	Spare batteries	Annually or as needed Logbook notation
Turbidometer	Before each sampling date	Battery life	Spare batteries	Annually or as needed Logbook notation
pH Meter	Before each sampling date	Battery life, level of electrolyte, integrity of probe	Spare batteries, electrolyte	Annually or as needed Logbook notation
Digital Titrator	Before each sampling date	Proper installation of cartridge, zero reset	Spare cartridges, dispensing tubes	Annually or as needed Logbook notation
Conductivity Meter	Before each sampling date	Battery life	Spare batteries	Annually or as needed Logbook notation

Equipment Type	Inspection Frequency	Type of Inspection	Available Parts	Maintenance, Corrective Action & Recordkeeping
Filtration Apparatus	Before each sampling date	Operation of vacuum pump, cleanness and completeness of equipment, sufficient filters, sterility (bacteriological samples)	Extra filters and hand pumps	Annually or as needed Logbook notation
Lab Benches	Before each sampling date	Cleanliness, cracks and chips	Patch or filler kit	Clean and disinfect before each analysis date

Formats To Use

This section can be completed in narrative format, or using the same format as the table above.

16. Instrument Calibration and Frequency

Identify how you will calibrate sampling and analytical instruments. Include information on how frequently instruments will be calibrated, and the types of standards or certified equipment that will be used to calibrate sampling instruments. Indicate how you will maintain calibration records and ensure that records can be traced to each instrument. Instrument calibration procedures for biological monitoring programs should include routine procedures that ensure that equipment is clean and in working order.

EPA, 1996

Purpose: To document that your instruments will record accurate measurements.

What To Include:

You should include the following:

1. **Equipment Type:** List each instrument you will use to measure the indicators.
2. **Calibration Frequency**: How often will you calibrate each instrument.
3. **Standard Calibration Used:** What standard will you be using to calibrate the instrument?
4. **Logbook Notation**: Note calibration in your logbook.
5. **Corrective Action to be taken:** Describe actions that you may take to resolve problems.

How To Decide What To Do:

Instrument calibration is checking the measurements of your instruments against known standards and adjusting the instrument if necessary. The standards could be a solution which contains known amounts of the indicator you are measuring or another reliable instrument or method. This needs to be done periodically so that you can trust the readings of the instruments. The frequency of calibration varies among instruments. In general, follow the manufacturer's manual. As noted in section 15, we suggest that you create a logbook to record equipment maintenance and calibration. You can present this information in table form as exemplified below (Table 16.1). Your procedures should be described fully in your SOPs.

Table 16.1. Example Calibration Procedures

Equipment Type	Inspection and Calibration Frequency	Standard of Calibration Instrument Used	Logbook Notation	Corrective Action
Calibrated Line	Annually	Tape Measure	Yes	Recalibrate or replace with calibrated line
D.O. Meter	Before each sampling period (e.g. biweekly, monthly, etc.)	Following manufacturers instructions Comparison against Winkler titration see SOP	Yes	Replace membrane or adjust instrument
Thermistor	Annually	Certified Thermometer	Yes	Replace or provide correction factor
Turbidometer	Annually Before each sampling	Formazin Standards Secondary Standards see SOP	Yes	Adjust instrument
pH Meter	Annually Before each sampling	Audit samples and certified lab meter comparison Known standards, MWWP unknown see SOP	Yes	Adjust instrument, clean electrodes, replace electrodes
Digital Titrator	Before each sampling	MWWP unknowns	Yes	Replace
Conductivity Meter	Prior to each use	Known Standards	Yes	Adjust according to manufacturer's recommendations
Spectrophoto-meter	Annually	Known Standards	Yes	Adjust according to manufacturer's recommendations
Balance	Annually Before each sampling	Annual certification Use of certified inspection standards before each use	Yes Yes	Adjust and recalibrate
Thermometer	Beginning and mid way through season	NIST-certified thermometer	Yes	Replace or provide correction factor

Formats To Use

This section can either be done in narrative form or using the format of the table shown above.

17. Inspection/Acceptance Requirements for Supplies

Describe how you determine if supplies such as sample bottles, nets, and reagants are adequate for your program's needs.

EPA, 1996

Purpose: To document that you will inspect small equipment items or consumable supplies to ensure that you will have adequate supplies and that they will be usable.

What To Include:

- Description of inspection routine upon receipt of supplies that you purchase.
- Description/schedule for inspecting supply inventory to determine if you have enough and if they are in good shape. This is particularly important at the beginning of the sampling season if you are using supplies left over from the prior year.

How To Decide What To Do:

In this section you should describe how you will manage your sample equipment and consumable supplies. Consider the following and briefly describe your activities in your QAPP.

Determine your quantity needs so you don't order too much or too little.

You should review the list of indicators you will be monitoring. Check that list against the recommendations for container and sample size to determine your container needs. Also check the list against the SOPs to determine the quantity of reagents and other materials that will be required. Estimate the quantity of material needed from the number of sites and sampling dates. Perishable supplies should be ordered in small amounts; most reagants should be ordered in sufficient quantity for one sampling season. Other material, such as sampling bottles, may be reused indefinitely as long as they are properly cleaned between uses and a bottle blank is analyzed. A factor in selecting the number of sample containers is the time interval between sampling and the time before containers are returned by the lab. Allow extras for expendable or breakable supplies. It may also be advantageous to provide collectors with a new set of supplies when they return with samples, as long as the collectors maintain the bottles and reagants under conditions that preserve the required cleanness and are safe from tampering by children or animals.

Verify the condition of consumables when they arrive

Check the condition of reagent containers, glass bottles, and other breakable materials. Be sure to check the expiration date of reagents. Write the date on reagent containers the first time you use them.

Keep an inventory of supplies

Purchases of all materials should be done by one person, preferably the project coordinator. The same person should verify the condition of the order when received. An inventory of all material

should be developed that includes not only the item and the number purchased but also the supplier, address and telephone, and the purchase price. This information will be useful in the event of emergency replacement or in ordering in following years.

If some materials are to be purchased by a contract lab, they should provide a statement regarding their procedures for maintaining an appropriate inventory of supplies.

Develop a checklist of items volunteers will bring to the field

It is recommended that the project coordinator develop a checklist for each volunteer of the items to bring into the field. This will help avoid forgetting key supplies and will make it easy for the volunteer to restock. Volunteers should also check the condition of breakable items before they go to the field. They should know where to go for replacement items.

After each use, the project coordinator should determine if any breakage or loss occurred. If some material is maintained by individual collectors, they should be queried about the status of their supplies.

Table 17.1. Recommended Inspection for Supplies.

Supplies	Inspection Frequency	Type of Inspection	Available Parts	Maintenance
Reagents	Before each sampling date	Visual inspection of quantity and expiration date	Spare, fresh reagents	Annual replacement at beginning of sampling season
Field and Lab sample sheets	Before each sampling date	Visual	Additional copies	
Thermometer	Before each sampling date	Integrity of column	Spare thermometer	Calibrate and replace as needed
Waders or Life Preservers	Before each sampling date	Visual inspection for damage	Patch kit	As needed
Macroinvertebrate Nets	Before each sampling date	Visual inspection for damage and cleanness	Roll of net material, extra bags	Annually or as needed Logbook notation
Sample Bottles	Before each sampling date	Integrity, cleanness and seal for nutrient bottles, verified sterility of bacterial sample bottles, equipment or rinsate blank for reused bottles (see Glossary)	One set of spare bottles	NA
Cooler	Before each sampling date	Cleanliness, Ice packs	NA	Annually or as needed

Formats To Use:

This section can be described in narrative form or use a table like the one above.

18. Data Acquisition Requirements

Identify any types of data your project uses that are not obtained through your monitoring activities. Examples of these types of data include historical information, information from topographical maps or aerial photos, or reports from other monitoring groups. Discuss any limits on the use of this data resulting from uncertainty about its quality.

EPA, 1996

Purpose: To ensure that any data you use but don't collect yourself has a known data quality and is consistent with your data quality objectives, that others can access these data, and that your use of the data is appropriate.

What To Include:

Refer back to Section 5 where you began the preparation of a study design. In that process, you accessed a variety of materials already available to aid in developing your study priorities. You may have found other material since then. Here is the place to enter the list of other information that you used throughout the development of your project but did not collect through monitoring. Include the following:

1. **The title of the document or name of the information**
2. **Where you obtained it and where others may find it**
3. **Notes on the quality of the outside information such as uncertainties and caveats**

Describe any uncertainties you have about the quality of the data you are using from other sources or your own historical data. This usually occurs when quality control data are not available. Describe any limitations you will place on your use of this external data, either because its quality is unknown or because it is of poor quality (or because of differences in study objectives, sample locations, etc.). For example: "The 1992 report lacks QC data and the authors are not available, so we will make no quantitative conclusions on water quality trends since 1992. We may use the data to develop some hypotheses about trends or qualitative statements.

The references in the list should be sufficiently specific and complete so that you or others can readily find the material. Even if a copy is available in your files, also indicate where you obtained the copy.

Formats To Use:

Information on outside data acquisition can be described in narrative form, lists or a table.

Preamble to Elements 19 through 24

Sections 19-24 of the EPA Guide can be rather confusing. It may help to remember that you don't have to complete them in sequence and you consider the four separate objectives of these chapters:

1) *Improve overall project performance*. Chapter 20 deals with checking how well volunteers, laboratories, and equipment are operating. It looks at *function*, not outcomes. Someone evaluates the various systems and components of your program and, when problems are found, makes corrections that are intended to make your program run better.

2) *Producing a good data set*. Chapter 19 covers the normal data management routines people do to prevent or minimize missing data or data errors – i.e. to avoid data mistakes in the first place. Chapters 22 and 23 describe how various people, usually project leaders, review the data sets that the activities described in chapter 19 generate (i.e. field and lab sheets, computer files). Reviewers are trying to find and correct (when possible) missing or erroneous data. Taken together, 19, 22 and 23 should produce as complete and accurate a data set as possible. Any problems that are not correctable are reported, in order to maintain scientific credibility for your program.

3) *Ensuring that any use you make of your data is justified.* In chapter 24, you decide if and how you will actually use your data. You review the "final" data set that has undergone scrutiny and screening described in the previous chapters. You compare it with your data quality objectives and determine whether you have to discard any data, what conclusions you can justifiably draw, what qualifications or reservations you want to place on your data, or what changes you might need to make in your data quality objectives.

4) *Report your results.* After you've run these various checks, you are ready to release your data. In Chapter 21 you describe the reports you will issue.

19. Data Management

Trace the path your data take, from field collection and lab analysis to data storage and use. Discuss how you check for accuracy and completeness of field and lab forms, and how you minimize and correct errors in calculations, data entry to forms and databases, and report writing. Provide examples of forms and checklists. Identify the computer hardware and software you use to manage your data. *EPA, 1996*

Purpose: To ensure that:

- You eliminate/minimize errors in recording/transferring data
- You don't lose data
- You can easily access data once you've stored it.

The outcome of these data management activities is a data set that:

- Has been error checked
- Exists in as both original data sheets and computerized form
- Is easy to access.

The list that follows contains all the elements that should be present in this section. Forms and checklists may be found at <http://www.umass.edu/tei/mwwp/qapp.html>.

What To Include:

Data management is a process that involves several steps:

1. **Raw Data: Describe how you will handle raw field and lab data sheets to prepare them for long term entry.** All field and lab data sheets should be signed and checked for completeness by the collector or analyst. Chain of Custody Forms follow the samples. Data sheets are also inspected by the QC officer as soon as they are received and the collectors are contacted if any problem is suspected. Lab analysts flag data and comment on any samples that did not arrive cool or have other questionable characteristics. They send their data sheets and Chain of Custody Forms to the project coordinator and the QC officer as soon as the results are in.
2. **Data Entry and Validation:** This involves getting your raw data into a computer so that you can store and retrieve them for analysis. It includes two steps:
   a. Entry: Data should be entered into a computer data management application; specify the name of the application.
   b. Validation: The entered data must be checked against the field and lab sheets to assure that they have been entered correctly and critically reviewed for

reasonableness, correspondence with data quality objectives, and appropriate qualification or censoring of suspect data..

3. **Data Storage**: Describe where and how the data will be stored. For example: The original data sheets (field, lab and chain-of-custody) and computer entries are held maintained at the organization's office. Disk back-ups and copies of data sheets are made of all the products and stored in a separate location. Paper copies are sent to the Monitoring Service Center office.

Formats To use:

This information can be described in narrative form.

20. Assessment and Response Actions

Discuss how you evaluate field, lab, and data management activities, organizations (such as contract labs) and individuals in the course of your project. These can include evaluations of volunteer performance (for example, through field visits by staff or in laboratory refresher sessions); audits of systems such as equipment and analytical procedures; and audits of data quality (e.g., comparing actual data results with project quality objectives).

Include information on how your project will correct any problems identified through these assessments. Corrective actions might include calibrating equipment more frequently, increasing the number of regularly scheduled training sessions, or rescheduling field or lab activities.

EPA, 1996

Purpose: To describe what you will do to evaluate volunteer and lab performance and what responses you will make to either correct problems or censor results that do not meet data quality objectives.

What to Include:

This section addresses how you will deal with the various processes of project management, sample collection, lab analysis, data management, and reporting. In other words, this section covers the assessment of how well people and organizations are following the QAPP and what response will be taken when they don't. Other sections address assessment of equipment, methods and data. Key elements in this section will be procedures for evaluating and remediating progress on the several elements in addition to monitoring that may be critical to the success of your project.

It is a good idea for the Project Manager, QA Officer and, perhaps, members of your technical advisory committee to confer on this. Review your overall program objectives and design, as you discussed in sections 5, 6 and 10. Depending on the type of program or project, you may want to develop procedures to address the following questions. In each case you should prepare a planned response for any of the program attributes that are found lacking.

Questions on the progress on various aspects of the project

- Is monitoring occurring as planned?
- Is there ongoing work to add other information pertinent to the project?
- Is there additional documentation via written commentary and photographs occurring alongside monitoring?
- Are new elements being proposed as more is learned?

Response may include adding more volunteers, clarifying the tasks, developing or improving written instructions and job descriptions for various tasks, seeking help in identifying new questions revealed by current results and/or identifying additional information needs.

Volunteer performance

- Is the Technical Advisory Committee functioning well? Is it developing new questions and aiding in the interpretation of data? Does it meet regularly and do its members assist staff as needed?
- Have all volunteers been observed as they sample their sites(s) by the QA Officer, Project Manager or a Technical Advisory Committee member familiar with the monitoring protocols?
- Are volunteers collecting samples consistent with the project schedule and delivering samples within appropriate times? Is there a workable plan in place for dealing with adverse weather or other unplanned difficulties in sample collection? Are volunteers properly filling out data sheets?

Response might include reinforcing the TAC with additional experts, developing special working committees or targeting members for special tasks. The motivation of volunteers might be increased by special events recognizing their efforts, news releases, or attention from the Project Manager. If sample collection practices that do not conform to the QAPP are observed, retraining must be scheduled as soon as possible. Retraining might occur during the observation period or in a special session shortly afterward. Volunteers should be queried as to special unforeseen difficulties in meeting collection demands and assistance developed.

Laboratory performance

- Has the Project Manager or QA Officer observed lab work on project samples? Is the observed work consistent with the lab QAPP?
- Does the lab conform to its stated accuracy and precision goals? Are samples analyzed within acceptable holding times?
- Are the results provided in understandable and usable forms and in timely fashion?
- Is the sample delivery process working properly?

Response might include discussions with the lab to improve performance in those areas identified as deficient.

Data quality assessment

Data quality assessment should begin with the arrival of the first data sheets because the sooner problems are discovered, the less effort will be wasted. Is an immediate review of data sheets provided by the QA Officer? Are data quality statistics developed on an ongoing basis so that compliance with data quality objectives is continually assessed?

Response might include developing a quick scan of all data sheets by the QA Officer as soon as they are provided, procedures for developing quality control statistics semi-automatically from the database so that new data can be evaluated immediately and review of all performance audit samples.

Data management

- Are data being entered into the data management system in timely fashion and original copies archived in a safe place?
- Are QA practices developed to provide quick assessment?
- Are the data available to project personnel who need them?
- Are data backups regularly performed and stored in a separate location?

Response might include adding one of those young computer users as a volunteer to develop data management procedures, sharing information via the internet on a routine basis, and double checking regularly that backups are made and archived.

Reports

Has someone taken responsibility for developing reports? These should include media releases. Full data reports should not be frequently released to the public unless a plan is in place for quality analysis prior to release, but reports on activities are not so constrained. Media releases announcing sampling dates, group meetings, etc. should be routine. Data reports require the joint efforts of the Project Manager, QA Officer, and Technical Advisory Committee, perhaps others. Is a system in place for this to occur at least annually?

Response might include assigning the public notices effort to one volunteer and creating the process for involving the Project Manager, QA Officer and TAC in the development of an annual data report.

Formats To Use:

This section should be presented in narrative form.

21. Reports

Identify the frequency, content, and distribution of reports to data users, sponsors, and partnership organizations that detail project status, results of internal assessments and audits, and how QA problems have been resolved.

EPA, 1996

Purpose: To demonstrate that your data will actually reach your intended data users in a timely fashion and in useable form.

What To Include:

A brief description of the reports you intend to produce, reporting frequency and schedule, collaborators, and report recipients. Interpret the term report broadly to include things such as press releases, public presentations, exhibits, etc.

How To Decide What To Do:

Reports should be of the following types:

Internal reports should occur between the Project Manager and QA Officer following every volunteer and lab data report regarding the quality of that sampling periods data. The QA Officer should report on the ongoing evaluation of meeting data quality objectives. This should be done frequently during the sampling season so that interim corrections may occur. The Project Manager should report to the TAC on the status of the project following a mutually agreed to schedule. One of these reports should follow the completion of the sampling year and another should be provided when a draft annual report is ready. Membership reports might take several forms: a newsletter, an annual conference or a web page update. Prior to each sampling date, each volunteer should receive a reminder and encouragement. Responsibility for each report should be delegated and described in the QAPP. **Reports to the sponsor** should follow sponsor guidelines. These guidelines will likely include requirements to include all data and QA/QC results. This will be the Project Manager's responsibility.

Reports to the interested public and volunteer membership are typically the annual report and other special reports that include significant detail and lay out methods, quality control, and results for future use. The QAPP should outline the various responsibilities of the Project Manager, QA officer and TAC in developing these reports. Contract requirements may include agency review for some external reports.

Reports to the media serve to develop and enhance public awareness of the project's goals and findings. The QAPP should include a description of how the media connection will be made and maintained, the project contact person and the audience that should be reached.

Additional information on developing a variety of presentations may be found in "Ready, Set, Present! A Data Presentation Manual for Volunteer Water Quality Monitoring Groups" available from MWWP or on the web <http://www.umass.edu/tei/mwwp/datapresmanual.html> (MWWP, 1999).

Formats To Use:

This can be most easily presented in a narrative.

22. Data Review, Validation, and Verification

State how you review data and make decisions regarding accepting, rejecting, or qualifying the data. All that is needed here is a brief statement of what will be done, by whom.

EPA, 1996

Purpose: To establish accountability for your data system by describing who is in charge of reviewing and accepting data.

What To Include:

State what data are being reviewed (i.e. field and lab data), who's conducting the review, and who decides whether to accept, qualify or reject data. Many QAPP writers combine this section with section 23.

How To Decide What To Do:

Data need to be reviewed at several stages in the project.

Field data should be initially reviewed as soon as possible after collection by a field supervisor or the Project Manager. Completeness is evaluated. If necessary resampling and analysis may be possible. There should be an established protocol for deciding on resampling.

Laboratory data should be reviewed by the QA Officer as soon as possible after analysis. Completeness is evaluated. Data on field duplicates, lab duplicates, and other quality control measures should accompany the sample data. If discrepancies that exceed the data quality objectives are observed, reanalysis may be possible, as long as additional sample material is available and holding times have not been exceeded.

The combined data set should be reviewed after the field collection date by the QA officer and Project Manager using all available QC data. Deviations should be flagged. Incomplete data should be noted and the volunteer reminded that complete data logs are necessary. Calculations should be spot-checked. QC results that deviate from the data quality objectives will call the validity of the individual data or all related data into question.

The final decision on whether to include or reject the data should be made by the Project Manager and QA Officer.

Formats To Use

This information is best presented as a brief narrative.

23. Validation and Verification Methods

Describe the procedures you use to validate and verify data. This can include, for example, comparing computer entries to field data sheets; looking for data gaps; analyzing quality control data such as chain of custody information, spikes, and equipment calibrations; checking calculations; examining raw data for outliers or nonsensical readings; and reviewing graphs, tables and charts. Include a description of how errors, if detected, will be corrected, and how results will be conveyed to data users. *EPA, 1996*

Purpose: To ensure data users that you have a plan in place to scrutinize the quality of your data set, are prepared to evaluate your results vs. your data quality objectives, and that any data quality problems you encounter will be discussed when you issue project reports.

What To Include:

In section 22, you stated that you will have data review procedures and who will conduct them. In this section, you provide the details on what those procedures are. Primarily what you are doing here is describing the process you will use for going over all your records, compiling, consolidating and reporting information on the status or quality of your data set. Specifically you are identifying and possibly weeding out problematic individual data points. Sometimes you can also fix problems at this stage, but primarily you are flagging things: "This part of the data set is OK, these dates or samples are missing, these data are suspect, these are clearly bad". All this is a preparation for the next step (Section 24), where you make important *decisions* on how you are going to use the data you have just evaluated. Section 23 is similar in concept to what you do at tax time: compile and review all your bank checks, receipts etc., deciding what constitutes valid business expenses, charitable contributions, etc. so that you can determine your total income, deductions, and taxes due.

You will describe:

- what data are reviewed (i.e. field and lab sheets, QC reports, computer data, chain of custody forms, etc.)
- Who reviews them and when
- How you plan to report any 'data quality' problems that you find in this step.

Some of the steps mentioned below will have been described in other sections of your QAPP. They are included here to demonstrate a comprehensive program of data verification and validation, which all members of your program participate in to some extent. It would be wise to concentrate in section 23 on the data review conducted by supervisory personnel, such as a field coordinator, laboratory manager, project manager or QC officer.

How to Decide What to do:

Here's a sample list of checkpoints that focus specifically on verifying data (making sure the recorded results correspond to what you actually sampled) and validating data (e.g. producing a

set of data that have been accepted as "field qualified" or "lab qualified").

Project Supervisors (i.e. field or lab coordinator, project manager, etc.) are responsible for double-checking the data that field, lab, and data entry personnel submit (or produce). This occurs at several stages in the operation of the program.

- When samplers and analysists complete their respective tasks: Collect all the volunteers' data sheets at the end of or shortly after each collection date or analysis run. Look for the same things the field and lab personnel themselves were reviewing. This gives you a second set of eyes. Also, compare vs. the sampling plan, to see if any data are missing. If so, is this because data records were lost or because samples weren't taken? Remember to review chain of custody information. Flag any data where holding time and sample handling protocols were violated.
- When QC data are reported: Compare number of QC tests performed with number promised in sections 7, 11, 13 and 14. Compare test results with targets or expected values. Spot check calculations. Note all problems.
- When data have been entered into the computer and when graphs are generated: This should also happen shortly after each sampling date (i.e. don't wait until the end of the sampling season to do computer entry). Data review should also occur when any new summary data are produced (for instance, when creating a seasonal or end-of-year chart comparing data among sites or between sample dates). Check for disparities between different data renditions (did numbers change from field to lab to computer table to graph or chart?) Spot check calculations again. Check again for any outliers (computers can be programmed to visually highlight outliers for you).

Response activities will vary, depending on the problem and the specifics of your program. They may include:

- Locate lost data sheets; call sampler to clarify illegible readings.
- Resample when possible
- Flag or screen data. Some data may be so 'bad' that it's discarded at this point.

Generally, though, this section is concerned with identifying and reporting problems. You will be making notations that are used in section 24 when you compare your data results with your objectives and decide what do to about it.

Formats To Use:

Either a narrative or a table (Table 23.1) may be used to summarize this information.

Table 23.1. Example Table of Verification and Validation Procedures.

Verifying Group (name and address for all personnel, if not listed elsewhere)	**When**	**Activity**	**Possible Corrective Measures and Notification**
Field coordinator	Sampling day - when samplers turn over their data sheets	Collect, review volunteers' field sheets for 1. outliers 2. illegible data entries 3. missing data (compare vs. sampling plan)	1, 2. Discuss with samplers. Correct simple problems (e.g. illegible entries). Go to site to re-sample, if possible. Flag problems that are not correctable. 3. Discuss with samplers, locate any missing sampling sheets. If possible, go to site to sample where volunteers missed a collection. Flag any problems that are not correctable.
Lab coordinator	See above	Same steps as described for field coordinators; do this for lab sheets.	See above
Field or lab coordinator	At end of sample / analysis day	Review chain of custody sheets. Check for samples that exceeded holding time, arrived in improper condition (i.e. too warm, contaminated)	Resample or re-analyze if possible. Flag any problems that are not correctable.
Project leader or QA officer	When QC data are reported.	1. Compare number of QC tests performed vs. number promised in QAPP 2. Compare QC test results with targets or expected values. 3. Spot check calculations.	1. Check to see if any QC results sheets are missing. 2. Check equipment Re-run calculations 1-3. If possible, re-run QC tests. Flag any problems that are not correctable.
Data officer, project, leader, or QA officer	Shortly after each sampling date, when all data have been entered into the computer and when graphs are generated. Do this also when any new summary data are produced (for instance, when creating a monthly or end-of-year chart comparing data among sites or between sample dates).	Check for any changes in values from field sheets to lab sheets to computer table to graph or chart Spot check calculations again. Check again for any outliers	Correct any errors found, flag uncorrectable problems.

24. Reconciliation with Data Quality Objectives

Once the data results are compiled, describe the process for determining whether the data meet project objectives. This should include calculating and comparing the project's actual data quality indicators (precision, accuracy, completeness, representativeness, and comparability) to those you specified at the start of the project, and describing what will be done if they are not the same. Actions might include discarding data, setting limits on the use of the data, or revising the project's data quality objectives.

EPA, 1996

Purpose: To describe the process of how you will determine whether you have met your data quality objectives and what decisions you will make about the use of your data.

Remember that a QAPP is a living document, that is, it is meant to be modified as your project develops. In section 7, you set data quality objectives for your project. Now you will discuss how you plan to compare your actual results with your promises.

What to Include:

- List who will evaluate your actual data vs. your data quality goals.
- State how and when this will be done.
- Describe the process for determining what to do if goals are not met.

How to Decide What to Do:

There are five basic steps in this process:

1. Review your data quality objectives and sampling design, principally sections 6 and 7 but following parts, as well. It is recommended that the Project Manager, QA Officer, Technical Advisory Committee and outside reviewers should participate in this stage.

2. Conduct a data technical analysis review. This should involve the Project Manager and QA Officer. Use the information generated in section 23 to:

   - Do an initial check to decide which data must be thrown out. This can occur for a variety of reasons: a single data point is discarded because sample container was contaminated or sample exceeded holding time was exceeded; a whole set of analyses were discarded because the lab failed a QC test, etc.

   - Check your records for information on things like sampling sites and methods, time of sampling, weather conditions, etc. Did you have to change sampling sites unexpectedly or use non-standard equipment? Does this render any of the data unsuitable for comparison with either your own data set or with other studies, as discussed in section 7 on comparability?

- Run analyses of accuracy and precision for the remaining data and for the relevant parameters. See section 7 for guidance on what analyses to perform. Based on poor accuracy or precision results, determine whether any other data must be thrown out.

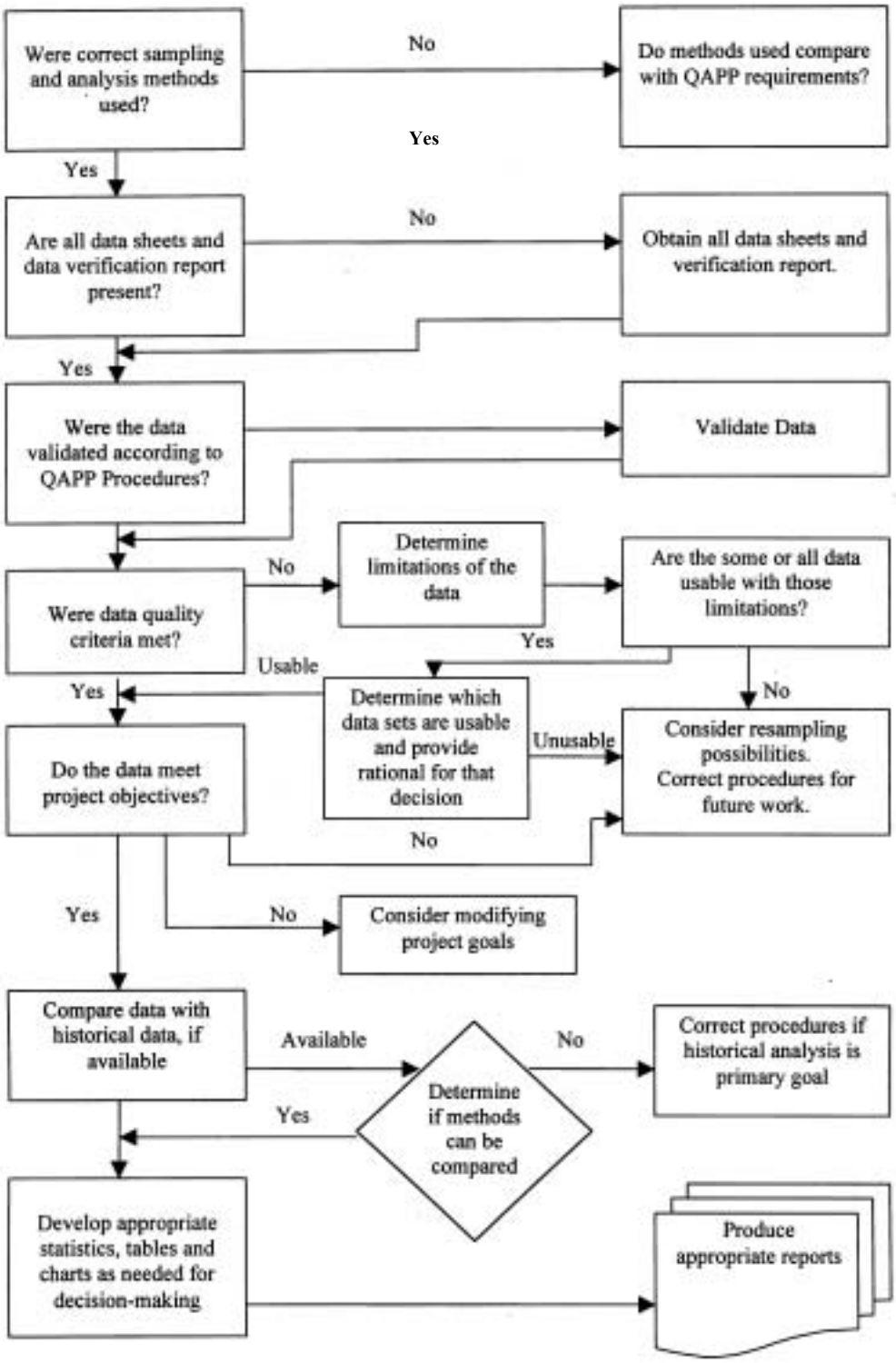
3. Now you have a 'final' data set (i.e. your original, intended data set minus any missing and invalid data). Evaluate you data set for completeness. (Do you have the number of samples you stated you would need for each condition – e.g. enough wet weather and dry weather samples).Appropriate statistical tests of the above data should be selected with the help of your Technical Advisory Committee or a Monitoring Support Center and result. You should list those tests and describe how you will decide to include, exclude or limit use of your data, depending on the results of the QA/QC analysis (refer to Data Quality Objectives, Section 7). You should include how you plan to reconcile your decision with your membership.

4. You should verify the assumptions you made about this project. These assumptions might include assumptions you made about volunteer capability, choice of methods, cooperation of the various partners, and the definition of the problem.

5. Finally, you should describe how you plan to draw conclusions from the data. These might include the use of: statistical or graphing procedures, simplified water quality indicators, comparison to water quality standards, trends, etc.

The following diagram (Table 24.1) modified from the EPA-New England QAPP guidance document (U.S. EPA, 1999) demonstrates the process.

Table 24.1. Data Review Decision Tree



Format to Use:

Following are examples of data reconciliation tables you can use to summarize how you will reconcile your data with your objectives and how you will respond if you don't meet them.

Table 24.2. Example of QA Form: Data Quality Objective Contingency Plan.

Parameter/ units	Corrective action planned if accuracy/precision objective not met	Planned Response if Completeness Objective Not Met
Temperature ^{o}C	Give thermometers a correction factor to improve their accuracy	Train back-up samplers
Dissolved Oxygen (mg/l)	Replace reagents Retrain analysts	Train back-up volunteers Maintain greater inventory of chemicals and sample bottles
pH Standard units	Check and recalibrate meter	Provide backup pH electrode
Conductivity (µmhos/cm)	Check and recalibrate meter	Provide additional laboratory help so that holding time can be met.
Turbidity (JTU)	Check and recalibrate meter with primary standards	Have battery replacements available

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Important Concepts and Elements of an Adequate State Watershed Monitoring and Assessment Program.* State of Ohio Environmental Protection Agency. Columbus, OH 43228. 38pp.

* Asterisked publications available on the web. Check <http://www.umass.edu/tei/mwwp/qapp.html>.

Appendix 1: Sources of Information

This appendix lists the statewide Monitoring Support Centers and other sources of information on quality assurance.

State and Federal QAPP Contacts

EPA:
Manager, EPA New England Quality Assurance Unit
Ms. Carol Wood
US EPA
11 Technology Drive
N. Chelmsford, MA 01863-2431

Steve DiMattei, US EPA
US EPA
11 Technology Drive
N. Chelmsford, MA 01863-2431
phone (617) 918-8369;
fax (617) 918-8397;
dimattei.steve@epa.gov

Arthur Clark, US EPA
US EPA
11 Technology Drive
N. Chelmsford, MA 01863-2431
phone: (617) 918-8374
fax: (617) 918-8397
clark.arthur@epamail.epa.gov

MA DEP Quality Assurance Officer(s)
Arthur Screpetis, MA DEP
627 Main St., 2nd Floor
Worcester MA 01608
508-767-2875
arthur.screpetis@state.ma.us

Richard Chase
627 Main St., 2nd Floor
Worcester, MA 01608
508-767-2859
fax: 508-791-4131
richard.chase@massmail.state.ma.us

Watershed Teams
EOEA Watershed Team Leaders

Blackstone	Lynne Welsh	(508)835-4816x503	lynne.welsh@state.ma.us
Boston Harbor	Karl Pastore	(617) 626-1165	karl.pastore@state.ma.us
Buzzards Bay	David Janik	(508) 946-8990	david.janik@state.ma.us
Cape & Islands	Patti Kellog	(508) 946-2812	patti.kellogg@state.ma.us
Charles	Sara Cohen	(617) 626-1067	sara.cohen@state.ma.us
Chicopee	Paul Lyons	(413) 323-8998	paul.lyons@state.ma.us
Connecticut	John O'Leary	(413) 587-9329	joleary@state.ma.us
Deerfield	Christine Duerring	(413) 773-7899	christine.duerring@state.ma.us
Farmington & Westfield	Michael Parker	(413)532-4450	michael.parker@state.ma.us
French & Quinnebaug	John Desmond	(508)767-2787	john.desmond-eqe@state.ma.us
Hudson & Housatonic	Tom O'Brien	(413)447-9771	tom.obrien@state.ma.us
Ipswich & Parker	Richard Tomczik	(978)661-7817	richard.tomczyk@state.ma.us
Merrimack & Shawsheen	William Dunn	(508)767-2799	william.dunn@state.ma.us
Millers	Alice Rojko	(508)792-7470x3855	alice.rojko@state.ma.us
Nashua	Jo Anne Carr	(508)835-4816x501	joanne.carr@state.ma.us
North Coastal	Larry Gil	(978)661-7746	lawrence.gil@state.ma.us
South Coastal	George Zoto	(508)946-2739	george.zoto@state.ma.us
SuAsCo	Mike Fleming	(978)368-0126	mike.fleming@state.ma.us
Taunton	Patrick Rogers	(508)946-2836	patrick.rogers@state.ma.us
Ten Mile & Narragansett	Andrea Langhauser	(508)946-2878	andrea.langhauser@state.ma.us

Statewide Monitoring Support Centers

Regional Monitoring Support Centers exist for much of the state, but these are subject to change. For a current list, contact John Clarkeson at the Executive Office of Environmental Affairs (EOEA), 251 Causeway Street, Boston, MA 02114; telephone: 617 626-1175; e-mail: john.clarkeson@state.ma.us or check the MWWP web site: <www.umass.edu/tei/mwwp/msc.html>

Massachusetts Water Watch Partnership

Blaisdell House, UMass Box 30820, Amherst, MA 01003-0820

Jerry Schoen	Marie-Françoise Walk	
jschoen@tei.umass.edu	mfwalk@tei.umass.edu	http://www.umass.edu/tei/mwwp
(413)545-5532	(413)545-5531	

Geographic Area Served: General needs for all Massachusetts watersheds and more specific needs for all watersheds west of and including the Connecticut River

Mission: The Massachusetts Water Watch Partnership (MassWWP) provides training and other technical assistance to citizen organizations who conduct water quality monitoring programs on the lakes, rivers, and estuaries of Massachusetts

Services provided:

- Development of standardized protocols for volunteers measurement of a variety of physical, chemical, and biological water quality parameters
- Production of manuals and videos on monitoring methods
- Consultations on study designs for individual watershed monitoring surveys
- A quality control program for field sampling and laboratory methods
- Workshops to train citizen groups to sample, analyze, interpret data and present findings to diverse audiences.
- An annual Conference for monitors to meet, learn, and share experiences
- Monitoring equipment on loan
- Distribution of publications and loan of video tapes
- Purchase of some equipment and videotapes

Environmental Analysis Laboratory

University of Massachusetts
Blaisdell House
Amherst, MA 01003-0820
(413)545-2936
pkerr@tei.umass.edu http://www.umass.edu/tei/wrrc/EAL.html

Geographic Area Served: Statewide for quality control, western Mass for analyses

EAL conducts a wide variety of inorganic analyses. The samples might include water, sediment or tissue samples.

Services provided:

7. Quality control program for pH, ANC, and DO
8. Water sample analysis for Total Phosphorus and Chlorophyll
9. Metal analysis
10. Fecal Coliform analysis (in development)
11. Chemical analyses advice

Guidance Documents

EPA Guidance Documents

Streams: Volunteer Stream Monitoring: A Methods Manual
<http://www.epa.gov/owow/monitoring/volunteer/stream/>

Lakes: Volunteer Lake Monitoring: A Methods Manual
<http://www.epa.gov/owow/monitoring/lakevm.html>

Estuaries: Volunteer Estuary Monitoring Manual
<http://www.epa.gov/owow/estuaries/monitor/>

Massachusetts Water Watch Partnership

Massachusetts Water Watch Partnership Home Page <http://www.umass.edu/tei/mwwp>

Guidelines for Subwatershed Groups Preparing Scientific Study Designs
<http://www.umass.edu/tei/mwwp/acrobat/studydesign.PDF>

Ready, Set, Present! A Data Presentation Manual for Volunteer Monitoring Groups
<http://www.umass.edu/tei/mwwpdatapresmanual.html>

Starting a Volunteer Monitoring Program. Ten Steps to Successfully Establishing a Volunteer Monitoring Program <http://www.umass.edu/tei/mwwp/starting.html>

VEMN Guidance Documents

Watershed Study Design Workbook
<http://www.umass.edu/tei/mwwp/acrobat/studydesign.PDF>

Guide to Volunteer Watershed Monitoring Options
<http://www.umass.edu/tei/mwwp/qapp.html>

State Agencies

Environmental Protection (MADEP) <http://www.state.ma.us/dep/>

Environmental Management (MADEM) <http://www.state.ma.us/dem/>

Fisheries, Wildlife and Law Enforcement (MADFWELE) <http://www.state.ma.us/dfwele/>

MassGIS <http://www.state.ma.us/mgis/>

Water Resources Research Center <http://www.umass.edu/tei/wrrc>

QAPP Forms

Sample Labels <http://www.umass.edu/tei/mwwp/acrobat/bottle-label.pdf>

Chain of Custody <http://www.umass.edu/tei/mwwp/acrobat/chainofcustody1.pdf> or <http://www.umass.edu/tei/mwwp/acrobat/chainofcustosdy2.pdf>

Lab Data Sheet <http://www.umass.edu/tei/mwwp/acrobat/labdatasheet.pdf>

Standard Operating Procedures (SOPs) for field and lab <http://www.umass.edu/tei/mwwp/sop.html>

Other Resources

EPA QAPP document <http://www.epa.gov/owow/monitoring/volunteer/qappcovr.htm>

Massachusetts Surface Water Quality Standards Regulations <http://www.state.ma.us/dep/brp/wm/files/314cmr4.pdf>

Massachusetts Impaired Waters List (303d) <http://www.state.ma.us/dep/brp/wm/files/finalist.pdf>

MWWP Windshield Watershed Survey <http://www.umass.edu/tei/mwwp/acrobat/shoreline-survey.pdf>

Riverways Shoreline Survey for Volunteers <http://www.state.ma.us/dfwele/river/rivAAS_survey.htm>

Topographic Maps <http://www.umass.edu/tei/esio>

Land Use <http://www.state.ma.us/mgis>

Population Data <http://www.umass.edu/miser/dataop/data.htm>

EPA New England <http://www.epa.gov/region1/> and <http://www.epa.gov/surf3/>

DEP Publications <http://www.state.ma.us/dep/brp/wm/wmpubs.htm#other>

DEP NPDES reports <http://www.state.ma.us/dep/dephome.htm> and select the DEP region

DEP List of Certified Labs <http://www.state.ma.us/dep/bspt/wes/files/certlabs.pdf>

EPA acceptable kits <http://www.umass.edu/tei/mwwp/acrobat/kits.PDF>

Sources of Bacteriological Audit Samples <http://www.umass.edu/tei/mwwp/qapp.html>

Providers of audit samples for bacterial proficiency testing

Microcheck, Inc. NVLAP Lab Code: 200391-0
142 Gould Road
Northfield, VT 05663
Contact: Dr. Michael G. Sinclair
Phone: 877-934-3284
Fax: 802-485-6100
E-Mail: ColiPT@microcheck.com
Send E-Mail to Laboratory: Microcheck, Inc.
URL: http://www.microcheck.com

Chrisope Technologies, A Division of Remel NVLAP Lab Code: 200388-0
3941 Ryan Street
Lake Charles, LA 70605
Contact: Ms. Jody D. Moss
Phone: 318-479-1000 x236
Fax: 318-479-1006
E-Mail: jdmoss@remelinc.com
Send E-Mail to Laboratory: Chrisope Technologies, A Div. of Remel

NYS DOH Environmental Laboratory Approval Program NVLAP Lab Code: 200387-0
Empire State Plaza
P.O. Box 509
Albany, NY 12201-0509
Contact: Dr. Kenneth W. Jackson
Phone: 518-485-5570
Fax: 518-485-5568
E-Mail: jackson@wadsworth.org
Send E-Mail to Laboratory: ELAP NYSDOH, Wadsworth Center
URL: http://www.wadsworth.org/labcert/elap.html

Environmental Resource Associates (ERA) NVLAP Lab Code: 200386-0
5540 Marshall Street
Arvada, CO 80002
Contact: Mr. Charles Wibby
Phone: 303-431-8454
Fax: 303-421-0159
E-Mail: eracxw@aol.com
Send E-Mail to Laboratory: Environmental Resource Associates
URL: http://www.eraqc.com

For other analytes: http://ts.nist.gov/ts/htdocs/210/214/scopes/calchem.htm

Appendix 2. Glossary Of QAPP Terms

The following are terms used in this Guidebook or commonly encountered in the development of a QAPP. They are provided by MADEP's Division of Watershed Management.

Accuracy: A data quality indicator, accuracy is the extent of agreement between an observed value (sampling result) and the accepted, or true, value of the parameter being measured. High accuracy can be defined as a combination of high precision and low bias.

Analyte: Within a medium, such as water, an analyte is a property or substance to be measured. Examples of analytes would include pH, dissolved oxygen, bacteria, and heavy metals.

Bias: Often used as a data quality indicator, bias is the degree of systematic error or inaccuracy present in the assessment or analysis process. When bias is present, the sampling result value will differ from the accepted, or true, value of the parameter being assessed in one direction.

Blind Sample: A blind sample is a sample submitted to an analyst without their knowledge of its identity or composition. Blind samples are used to test the analyst's or laboratory's expertise in performing the sample analysis.

Calibration Blank: Reagent-grade, purified water (deionized/distilled) used as a zero standard; used to "zero" lab instruments, evaluate instrument drift and check for sample contamination of field blanks.

Calibration Check Standard: A standard used to check the calibration of an instrument between periodic recalibrations.

Censored Data: Data that has been found to be unacceptable as a result of the data validation process, including review for conformance to the approved QAPP and data quality objectives for the project (ex. required holding times for analysis, required frequency of field blanks and duplicates/splits, acceptability of precision estimates (standard deviation, SD or relative percent difference, RPD).

Chain-of-Custody: Used for routine sample control for regulatory and non-regulatory monitoring. The chain-of-custody form contains the following information: sample IDs, collection date/time/samplers, sample matrix, preservation reqts., delivery persons/date/time, etc… Used also as a general term to include sample labels, field logging, field sheets, lab receipt and assignment, disposal and all other aspects of sample handling from collection to ultimate analysis.

Comparability: A data quality indicator, comparability is the degree to which different methods, data sets, and/or decisions agree or are similar.

Completeness: A data quality indicator that is generally expressed as a percentage, completeness is the amount of valid data obtained compared to the amount of data planned.

Data Quality Objectives (DQOs): Data quality objectives are quantitative and qualitative statements describing the degree of the data's acceptability or utility to the data user(s). They include indicators such as accuracy, precision, representativeness, comparability, and

completeness (PARCC). DQOs specify the quality of the data needed in order to meet monitoring project goals.

Data Users: The group(s) that will be applying the data results for some purpose. Data users can include the principle investigators, as well as government agencies, schools, universities, watershed organizations, and business and community groups.

Detection Limits: Applied to both methods and equipment, detection limits are descriptions of the lowest concentration of a target analyte that a given method or piece of equipment can reliably ascertain as greater than zero. Specific detection limits include: Instrument detection limit, level of quantitation, lower level of detection, method detection limit, practical quantitation limit and reporting detection limit.

Duplicate Sample: Used for quality control purposes, field/lab duplicate samples are two samples taken generally at the same time from, and representative of, the same site/sample that are carried through all assessment and analytical procedures in an identical manner. Field duplicate samples are used to measure natural variability as well as the precision of field sampling and lab analytical methods. Lab duplicates are used as a measure of method precision. More than two duplicate samples are referred to as replicate samples.

Environmental Sample: An environmental sample is a specimen of any material collected from an environmental source, such as water or macroinvertebrates collected from a stream, lake, or estuary.

Equipment or Rinsate Blank: Used for quality control purposes, equipment or rinsate blanks are types of field blanks used to check specifically for carryover contamination from reuse of the same sampling equipment (see field blank).

Field Blank Water: Deionized water made available by properly-maintained and -functioning water filtration system.

Field Blank: A field blank is created by filling a clean sample bottle with deionized or distilled water in the field during sampling activities. The sample is treated the same as other samples taken from the field. Field blanks are submitted to the lab along with all other samples and are used to detect any contaminants that may be introduced during sample collection, fixing, storage, analysis, and transport.

Field Composite Sample: A sample taken by mixing equal volumes of a pre-determined number of grab samples from the same location at different times, ie. a time-composite. Used to assess average conditions present between the first and last grab samples that are composited. Use time-composite sampling only for those parameters that can be shown to remain unchanged under the specific conditions of composite sample collection. Flow-weighted composite sampling is a variation to time-composite sampling, in which sample volume adjustments are made to each grab based on variations in flow, such as occurs during stormwater monitoring loading studies.

Field Integrated Sample: A sample taken by simultaneously combining a matrix across vertical or horizontal strata as an evaluation of average composition within the boundaries of the integration (ex. Photic zone sampling for chlorophyll a). Sampling tubes can sample continuous, integrated media.

Field Split: A second sample generated from the same sampling location and at the same time by splitting a large volume sample from one sampler deployment into two equal volume samples. Used to measure precision, except that associated with actual sample collection, and excludes natural variability. Also referred to as duplicate subsample.

Field Duplicate (sequential): A second sample generated from the same sampling location as the initial sample, but from a second sampler deployment immediately after the first. Used to measure overall field sampling precision and includes an unknown amount of natural variability (spatial and temporal), if present.

Field Duplicate (simultaneous): A second sample generated from the same sampling location and at the same exact time as the other sample by simultaneous deployment of two identical sampling devices or by the simultaneous filling of two separate sample bottles. Used to measure overall field sampling precision and includes an unknown amount of natural variability (spatial), if present. Also referred to as a co-located duplicate.

Grab Sample: A manually collected sample at a specific location and time. Given practical constraints and budget limitations, assumptions are usually made that the natural variation is small enough over space/time to consider the grab to be representative of conditions over a greater expanse and/or longer period. In some cases, these assumptions may not always be valid.

Instrument Detection Limit (IDL): The concentration that produces a signal greater than five times the signal/noise ratio of the instrument.

Lab Split: A sample that has been divided into two or more subsamples. Splits are submitted to different analysts or laboratories and are used to measure the precision of the analytical methods. Lab splits are an external QC protocol.

Lab Duplicate: A sample that has been divided into two or more subsamples. It is processed concurrently and identically with the initial sample by the same laboratory. It is used to measure the precision of the analytical methods. Lab duplicates are also referred to as lab splits.

Level of Quantitation (LOQ): The concentration that produces a signal sufficiently greater than the blank that it can be detected; typ. The concentration that produces a signal 10*s above the blank signal. Typically, ten times the IDL (SM, 1998) .

Lower Level of Detection (LLD): Measurement level reproducible with 99% certainty; typically twice the IDL.

Matrix: A matrix is a specific type of medium, such as surface water or sediment, in which the analyte of interest may be contained.

Matrix Spike: A sample to which a known concentration of target analyte has been added. When analyzed, the difference in analyte concentration between a spiked sample and the non-spiked sample should be equivalent to the amount added to the spiked sample. Lab QC sample used to assess sample matrix effects on recovery of target analyte and evaluate accuracy. Also known as Lab-fortified matrix. Duplication of this sample is referred to as matrix spike duplicate or lab-fortified matrix duplicate.

Measurement Range: The measurement range is the extent of reliable readings of an instrument or measuring device, as specified by the manufacturer.

Method Blank: An aliquot of clean reference matrix carried through the analytical process to assess the degree of laboratory contamination and indicate accuracy.

Method Detection Limit (MDL): The MDL is the concentration that produces a signal with a 99% probability that it is different from the blank, after going through the entire method. The smallest amount that can be detected above the noise in a procedure and within a stated confidence level. Typically, four times the IDL.

Method Validation: Testing procedure for existing, new and modified methods, in which several evaluation steps are typically employed: determinations of MDL, method precision, method accuracy, and sensitivity to variation in method steps ("method ruggedness", SM, 1998).

Performance Audit: Unscheduled evaluation of field sampling QC or laboratory QC procedures by a third party not directly involved in the taking, transport and analysis of the samples; used to detect deviations from accepted SOPs. Audits can take many forms. Submittal of identical check samples to two different labs is an example of an external, blind performance audit. Lab intercomparison samples can also be used to test the lab's proficiency in relation to other labs. Results of audits are documented and any necessary corrections recommended.

Performance Evaluation (PE) Samples: A sample of known concentration submitted "blind" (without lab's knowledge) to the analyst. PE samples are provided to evaluate the ability of the analyst or laboratory to produce analytical results within specified limits, and as an indicator of method accuracy. Also called a laboratory control sample.

Practical Quantitation Limit (PQL): The level that several labs can achieve using the same method and samples; typically, ten times the IDL, and 3-5 times the MDL.

Precision: A data quality indicator, precision measures the level of agreement or variability among a set of repeated measurements, obtained under similar conditions. Precision is usually expressed as a standard deviation in absolute or relative terms.

Protocols: Protocols are detailed, written, standardized procedures for field and/or laboratory operations.

Qualifier: Used to indicate additional information about the data, and generally denoted as capital letters in data reports. Qualifier acronyms or terms are unique to each laboratory.

Quality Assurance (QA): QA is an integrated management system designed to ensure that a product or service meets defined standards of quality with a stated level of confidence. QA activities involve planning quality control, quality assessment, reporting, and quality improvement. These activities can be internal (within the main group) or external (involving outside parties).

Quality Assurance Project Plan (QAPP): A QAPP is a formal written document describing the detailed quality control procedures that will be used to achieve a specific project's data quality requirements. A QAPP is a planning tool to ensure that project goals are achieved. Typically, QAPPs are finalized prior to monitoring activities and any deviations from the final QAPP made

during the actual monitoring are noted in a subsequent task, such as the data reporting phase of the project. QAPPs can be of two main types:

-- A "project-specific QAPP" provides a QA blueprint specific to one project or task and is considered the sampling and analysis plan/workplan for the project.

-- A "generic program QAPP" is an overview-type plan that describes program data quality objectives, and documents the comprehensive set of sampling, analysis, QA/QC, data validation and assessment SOPs specific to the program. An example is a macroinvertebrate monitoring program performed throughout many watersheds within a State.

Quality Control (QC): QC is the overall system of technical activities designed to measure quality and limit error in a product or service. A QC program manages quality so that data meets the needs of the user as expressed in a quality assurance project plan. Specific quality control samples include blanks, check samples, matrix spikes and replicates.

Random Sample: A sample chosen such that the choice of each event in the sample is left entirely to chance; an unbiased sample generally representative of the population. Randomness is a property of a sample that must exist for almost any statistical test, but may not be appropriate for all sampling designs (ex. Non-random site selection based on targeting specific conditions or based on practical considerations).

Relative Standard Deviation (RSD): A measure of precision calculated by dividing the std. deviation by the mean, expressed as a percentage. Used when sample number exceeds two.

Relative Percent Difference (RPD): A measure of precision used for duplicate sample results. It is calculated by dividing the difference between the two results by the mean of the two results, expressed as a percentage. Used when sample number equals two.

Reporting Detection Limit (RDL): The lower limit that the lab feels comfortable reporting with a high level of certainty. For practical purposes, the RDL is often equivalent to the MDL.

Representativeness: A data quality indicator, representativeness is the degree to which data accurately and precisely portray the actual or true environmental condition measured.

Sensitivity: Related to detection limits, sensitivity refers to the capability of a method or instrument to discriminate between measurement responses.

Spike Blank: Known concentration of target analyte(s) introduced to clean reference matrix and processed through the entire analytical procedure; used as an indicator of method performance and accuracy. Also known as Lab-fortified blank.

Standard Reference Materials (SRM): An SRM is a certified material or substance with an established, known and accepted value for the analyte or property of interest. Employed in the determination of bias, SRMs are used as a gauge to correctly calibrate instruments or assess measurement methods. SRMs are produced by the U. S. National Institute of Standards and Technology (NIST) and characterized for absolute content independent of any analytical method.

Standard Deviation(s): Used in the determination of precision, standard deviation is the most common calculation used to measure the range of variation among repeated measurements. The

standard deviation of a set of measurements is expressed by the positive square root of the variance of the measurements.

Standard Operating Procedures (SOPs): An SOP is a written, official document detailing the prescribed and established methods used for performing project operations, analyses, or actions.

Trend: Systematic tendency over time in a specific direction in time series data, ideally collected at uniform intervals, collected and analyzed using the same (or comparable) methods and containing no gaps in periodic data.

True Value: In the determination of accuracy, observed measurement values are often compared to true, or standard, values. A true value is one that has been sufficiently well established to be used for the calibration of instruments, evaluation of assessment methods or the assignment of values to materials.

Variance: A statistical term used in the calculation of standard deviation, variance is the sum of the squares of the difference between the individual values of a set and the arithmetic mean of the set, divided by one less than the numbers in the set.

Appendix 3. Example Field Data Sheets